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MALAYAN FOREST RECORDS

Mangrove Forests
OF THE
Malay Peninsula

WATSON

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No. 1. Aerial roots of RHIZOPHORA spp. at low tide. Compare plate 51.

MALAYAN FOREST RECORDS

No. 6

Mangrove Forests of the Malay Peninsula

BY

J. G. WATSON,

Deputy Conservator of Forests,

Federated Malay States.

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No. 6. 1928.

MALAYAN FOREST RECORDS.

MANGROVE FORESTS OF THE MALAY PENINSULA.

By J. G. Watson,

Deputy Conservator of Forests, F.M.S.

INTRODUCTION.

Like its immediate predecessor in the series, this *Record* is presented after many years of unavoidable delay. It originated in a bundle of manuscript handed to the writer by Mr. J. P. Mead on the eve of his departure to France in 1916, containing a mass of valuable first-hand observations made in the course of a good many years of experience of mangrove work in Perak and Selangor. When the necessary time could be spared these notes were typed and rearranged for publication. In the meantime, however, a considerable number of important changes had been made in the administration of the mangrove forests, and a good deal of fresh information had come to light. It was decided, therefore, that Mr. Mead's notes should be amplified, and that publication should take the form of a complete and up-to-date record, the compilation of which was started by Mr. G. E. S. Cubitt, Conservator of Forests, assisted by the present writer. Owing, however, to the extreme shortage of staff during and immediately after the war, it was not found possible to concentrate the necessary attention on the subject, with the result that the work had reluctantly to be set aside after a very considerable part of it had assumed what was then thought would be its final form.

From 1919 to 1924 little was done beyond the maintenance of a record of observations contributed from time to time by the different officers in charge of mangrove work. In 1925 the writer again took over the by now somewhat depressing mass of notes and out-of-date information, but it was not until 1927 that the task of correction and rewriting could be seriously taken in hand.

Introduction.

It is hoped that the references to literature and the infrequent use of the first person singular will convey the idea—even to those who do not read this introduction—that this *Record* is a compilation, and that the writer is its editor rather than its author. For obvious reasons it is not possible to acknowledge all contributions (many of them verbal) that have gone to the making of this book; but it would be ungenerous not to make special mention of Messrs. B. H. F. Barnard and A. E. Sanger-Davies, and not to give full credit to Messrs. V. P. Borges, D. H. Hodgson, A. B. S. Boswell, H. C. Dolman, and C. C. L. Durant, to whose efforts, ably seconded by Forest Rangers Elias, Yeop, Hitam, and Ahmad, may be attributed the present state of efficiency in the management of the mangrove forests.

I have to thank Mr. R. O. Bishop, late Agricultural Chemist, for his enthusiastic collaboration in the investigation of tan-bark problems and for the inauguration of experiments that were subsequently taken over and ably developed by Dr. T. A. Buckley, Assistant Forest Chemist. The results are briefly referred to in Chapter VI, but will be published in detail as a separate *Record*.

To Mr. W. H. Noble of the F.M.S. Survey Department I am indebted for the reproduction of the distribution diagram in Chapter IV, and to Messrs. Fraser & Neave, Singapore, and Lascelles & Co., London, for the high standard of the printing and illustrations.

J. G. WATSON,

Deputy Conservator of Forests,

Federated Malay States.

KUALA LUMPUR, *October, 1928.*

Chapter I.

GENERAL DESCRIPTION.

(*a*) Extent.

The mangrove forests (or swamps) of the Malay Peninsula cover an area of about four hundred and thirty square miles, almost all on the west coast. Over four hundred square miles have been constituted reserved forests, particulars of which will be found in Appendix A.

(*b*) Formation.

Schimper (*46), in his *Plant Geography*, has drawn attention to the correlation that exists between tropical rain forests and mangrove, in spite of the semi-xerophytic character of the flora of the latter. The apparent paradox that extensive mangrove forests are absent along coasts where the inland flora is of a xerophytic type is, he says, explained by the "physiological dryness" of sea water, and the consequent necessity for adaptations to guard against excessive transpiration. Rain forests denote heavy rainfall, with rivers bringing abundance of fresh water and silt to the sea, and they generally connote that cloudiness of the atmosphere that he regards as essential to the optimum development of mangrove. A point that Schimper does not sufficiently stress is the absence of large rivers in arid regions, and the consequent lack of carriers of rich silt for the mangrove to grow in. Disregarding the fact that all the species are inhabitants of the tropics, the determining factors in the ecology of the mangrove flora would, therefore, appear to be those connected with soil quite as much as those influencing transpiration.

Silt brought down by the rivers, and sand from the bed of the sea, are banked up by the combined action of waves, tides, and currents. When the banks have developed sufficiently they become covered with water-borne species, Avicennia (*api-api*) being usually the first to appear. The seeds of this genus, being semi-viviparous, are able to start growing at once and, with the help of their hairy radicles, successfully to withstand the scour of tide and current. Not so easy to understand is the ability of Sonneratia (*perepat*) to establish itself; for the seed is neither viviparous nor armed with any special anchoring device. Yet this species is certainly one of the pioneers in the formation of mangrove forests, particularly

* The numbers in brackets refer to the bibliography on page 237.

where there is a high percentage of humus mixed with the silt. Moodie (35) suggests that the small seeds, which do not float for any length of time, are carried along with the silt and deposited on the newly formed banks. Tree growth thus quickly covers the shoals, whose level is then more rapidly raised by mud and organic matter held up by the spreading network of roots, and by the peculiar development of the roots themselves. These banks are often entirely isolated, and may be some miles out to sea, the young trees being at first completely submerged twice daily, except during neap tides.

It is doubtful whether even *api-api* can withstand complete submergence twice every day for any length of time. The large expanse of unclothed mud exposed at low water suggests that it is necessary for the banks to remain uncovered for several days together before any form of land vegetation can establish itself. It is considered that the limit of tree growth is to be found round about the neap high-water mark, above which the ground remains unsubmerged for at least two days in every month. In rivers and sheltered situations the Rhizophoras may occupy flats that are covered by even the lowest neap tides, but here the superior length of the radicles enables even the seedlings to keep their heads above water.

Typical pioneer forests of Avicennia and Sonneratia are illustrated on page 3, where their numerous pneumatophores, protruding from the ground like asparagus, are clearly visible. These in time catch the floating seeds of other mud-loving species which have hitherto been unable to find a resting place and which, in any case, are unable to thrive in silt that has not been enriched by the less exacting kinds. In this way the Bruguieras and Rhizophoras of the mangrove forests proper are enabled, where the mud is soft and deep, to establish themselves and eventually to displace the pioneer species.

In spite of statements to the contrary made by Schimper (46) Haberlandt (22), and others, neither of the Rhizophoras normally occupies in Malaya positions exposed to the direct action of the sea waves, there being practically always a protective belt of Avicennia or Sonneratia along the seaward edge and, more often than not, a second line of defence in the shape of a low ridge of *berus* (*Bruguiera caryophylloides*). It is quite true, however, that the Rhizophoras are often the only species that can maintain a precarious existence in really exposed situations, such as the rocky or sandy foreshores of islands. But these are abnormal conditions, and the trees may be said to be doing their best under trying circumstances much as a shipwrecked sailor does his best on a barren desert



(a) Low tide.



(b) High tide.

2. The pioneer species in the formation of mangrove swamps. *Avicennia intermedia* (API-API PUTEH), showing spreading root system and asparagus-like pneumatophores.



3. PEREPAT (*Sonneratia Griffithii*) at low tide. At this stage the pneumatophores resemble those of Avicennia.

island. Like him, they have got there because they are good swimmers, but they are not pioneers in the sense that they are preparing the ground for other trees, any more than the shipwrecked sailor is preparing his desert island for castaways that may come after; and the chances of further propagation are about the same in both cases. In the same category can be placed the rhizophoras mentioned by Brown and Fischer (6) as having been planted successfully as ballast retainers by the side of the Florida Keys railway track. Changes of current or unusually heavy seas may sweep away the mud banks before the forest is fully formed, or even the mature forset may be eroded; but, generally speaking, accretion more than makes up for erosion, so that the mangrove belt is steadily advancing seawards and extending along the coast from either side of the river mouths. On the landward side it is as steadily retreating before the advance of the non-mangrove forests. In as much, however, as the silt deposits remain bare until they have attained very definite conditions of elevation and consistency, it is scarcely correct to regard the mangrove as the causative agent in the silting process. True, they accumulate deposits when once they have established themselves, and they may even check erosion at a later date, but the writer agrees with Becking Berger and Mindersma (1) that mangroves follow silting rather than cause it.

On the more exposed east coast the process of formation is somewhat different. Here the wave action is more severe, particularly during the north-east monsoon, so that any fresh water brought down by the rivers is more speedily dispersed. Mangrove forms are, therefore, unable to establish themselves along the beach and are confined to the river mouths, whilst the sandy beaches themselves are flanked by a narrow belt of *Casuarina equisetifolia* which extends practically unbroken from Singapore northwards to far beyond the limits of Malayan territory.

Where the flow of the river is sluggish the tendency is for banks of sand to be deposited at the mouth through the combined action of the currents and the north-east monsoon, the channel being forced thereby further and further south. The newly formed natural breakwater is speedily covered on its seaward edge with a dense growth of casuarina, and subsequently on its protected side by mangrove forms brought down by the river. The bank continues to advance in a southerly direction, until exceptional circumstances breach it and allow the water to escape by a new mouth. The old channel then rapidly silts up and soon becomes stocked with mangrove species which persist until a new bank is formed and again breached. The new channel is then in its turn converted into a mangrove swamp and the old one is invaded by inland forms.

Nearly all of the east coast rivers show this tendency. It is most marked at Rumpin, Merchong, and Bebar, where successive folds in the ground running parallel to the coast and bearing a few straggling casuarina on the ridges and decadent mangrove in the hollows, provide unmistakable evidence of former banks and swamps. The last mentioned river demonstrates this process particularly clearly, the abnormal floods at the beginning of 1927 having broken through the casuarina bank about 5 miles above the mouth of the previous channel, which is now beginning to silt up and be invaded by mangrove.

Most of the species have a wide distribution, accomplished by the agency of ocean currents. Guppy (21) gives an extremely interesting account of their dispersal in the Pacific, with particular reference to Fiji, where the most noteworthy feature is the occurrence of the American *Rhizophora Mangle* side by side with the Asiatic *R. mucronata*. Generally speaking, there are no forms that are common to these two main divisions. Though Guppy has satisfied himself by a large number of tests that the majority of seedlings can float unharmed in sea water for several months, he does not admit that the progenitors of the American species now inhabiting Fiji necessarily made the voyage across the Pacific. He considers it far more likely that *R. Mangle* formerly occurred over a far wider range, and that the Fiji trees are survivors of a species that is becoming extinct.

Schimper (47), on the other hand, regards *R. Mangle* as a degenerate form of *R. mucronata*, or possibly as a sister species. In either case he has little doubt of its Asiatic ancestry. On page 89 he says:

> "To my mind, the indubitable Asiatic origin of *R. Mangle* suffices to explain the relative richness and paucity of the Asiatic and American mangrove floras. Without Rhizophora, no typical mangrove can be formed; its species are the pioneers that prepare the soil for other species (*sic*). A similar but subordinate role might, perhaps, be ascribed to *Sonneratia alba*, which does not, however, occur in America. The remaining forms are only able to maintain themselves independently on the edges of sheltered lagoons and bays, and they only appear in the open when the *Rhizophoraceae*—particularly the two rhizophoras—have raised and consolidated the soil and broken the force of the waves. In this way, the Indian mangrove swamps, with their many forms of *Rhizophoraceae*, would have reached an advanced stage of development, and a number of other types would have adapted themselves to similar conditions, before the American mangrove flora came into being."

Whether or not Schimper is correct in his conclusions regarding the relative antiquity of the old and new world types and the Asiatic origin of the American species, it is certain (at anyrate as far as Malaya is concerned) that he is on more than doubtful ground with his basic assumption that the rhizophoras are the actual pioneers in the formation of the mangrove swamps.



3(*a*). Aerial photograph from 8,000 ft., showing seaward extension of Avicennia. The featureless portion in the centre is occupied by *Bruguiera caryophylloides*, with Rhizophora further inland. Kapar forest reserve, Sungei Serdang Besar, September 1926.

Photograph by Air Survey Co.



3(*b*). A typical *bagan* or fishing village. K. Larut.

Guppy's observations on the powers of resistance of mangrove seedlings might well be verified in this country. He alleges, with reference to Rhizophora, that nine tenths of the naturally fallen seedlings will float in sea water, mostly in a horizontal position, whilst only a half or three quarters will float in fresh water, in which they usually assume a vertical position. The seedlings of *Bruguiera gymnorhiza* are even more resistant than those of the Rhizophoras, and assume similar positions according to the salinity of the water. He considers that though it increases the risk of damage by impact on stranding, the horizontal position is more advantageous, since it partially submerges the tender plumule which, were the seedling to float vertically, would soon be dried up by the sun. His experience with stranded seedlings has been that they can retain their vitality for months under a covering of sand and *debris*, and that a large percentage can develop leaves and roots if planted in mud, even after having been kept quite dry for several weeks.

This last observation is not entirely in accordance with the behaviour of similarly treated seedlings in Malaya though, as will be seen from the reference to Philippine plantation methods on page 151, partial drying is regarded in that country as a desirable preliminary to planting and as a safeguard against damage from crabs.

(*c*) Topography.

On the west coast the mangrove belt is almost continuous from Kedah to Singapore. It varies in width from a few chains to a maximum of about twelve miles at the mouth of the Larut river in the Matang district of Perak; but the mangroves follow the rivers much further inland, extending along the banks of the Perak river up to Telok Anson, a distance of about thirty miles from the sea. The belt is intersected by numerous deep anastomising tidal creeks, which sometimes exceed a mile in width, and which cut off from the mainland islands varying in size from a few acres to more than thirty square miles. On the Perak coast there is a continuous inland waterway through the belt from Gula in the Krian district to Panchor on the boundary of the Dindings, a distance of over forty miles, while the main approaches to Port Swettenham (which lies at the back of a large mangrove swamp) are navigable by large ocean-going vessels at all states of the tide. Some of the islands, such as Pulau Trong and Pulau Klang, are entirely covered by mangrove; others, such as Pulau Lumut, Pulau Pasir Hitam, and Pulau

Gula, which stand somewhat higher out of the water, have in their interior sharply defined stretches of mixed forest of a more inland type, large areas of which have been alienated for coconuts and small holdings—including rice cultivation—within the last few years.

As already stated, the mangrove swamps of the east coast are confined to the mouths of the rivers, the beaches being sandy and open, and generally free from gregarious tree growth other than casuarina.

On many of the rocky islands mangrove types have established themselves in sheltered situations and demonstrated their ability to thrive, though not to reach their largest dimensions, in sand and even amongst rocks.

(*d*) ACCESSIBILITY AND SOIL.

Approach to the swamps is easiest from the landward side, where the mud is comparatively firm and rarely more than knee deep. Access from the sea is ordinarily impracticable, for, although at high tide the forest is innundated, at low tide the water is so shallow that a launch drawing six feet may be unable to approach within two or three miles, and the smallest boat within some hundreds of yards of the shore. There being no roots or pneumatophores to prevent the feet from sinking, and the mud, moreover, being composed of comparatively recent deposits and consequently very soft, it is only possible to cross these exposed mud flats in small flatbottomed boats known as *sampan itek* or *sampan lopek*, or in the scooter-like sledges (*tongkah*) used by cockle gatherers in some of the Perak swamps. But neither of these two forms of conveyance is suitable for the transport of anything weighty, even a single passenger in the boat making the work of the single rower arduous in the extreme.

In exceptionally well-favoured localities, where erosion has removed the softer mud and provided deeper access and a firm foreshore above the level of medium high tides, and where extraction canals can be dug and maintained at reasonable cost, extraction via the sea is practicable. But even here the position is complicated by the necessity of providing loading facilities for boats of sufficient size and seaworthiness to carry a full cargo with reasonable safety in the open sea.

Sandy beaches are the rule along the east coast, but the exception in the west, where they are usually the result of erosion and likely to be re-covered with mud when (as frequently happens) erosion is followed by accretion.

In the fully established forest one seldom sinks above the ankles, and walking, though unpleasant, is arduous chiefly on account of the obstructions offered by stilt roots, pneumatophores, or *piai* fern. At high tide, many of the smaller creeks by which the swamps are intersected can be entered by a launch or motor boat, and approach to and extraction from the forests is thereby much facilitated. At spring tides only the driest *tumu* and *berus* areas remain unsubmerged.

(*e*) POPULATION.

Parts of the mangrove area are well populated. Some of the largest permanent Chinese fishing villages (*bagan*), such as that on Pulau Ketam in Selangor, have several thousand inhabitants. Malay fishermen from other parts of the peninsula visit the area in pursuit of their calling for part of the year, and there is a shifting population of some hundreds of woodcutters, who live in temporary barracks. The Chinese villages are all lapped by the tide or may even be completely surrounded by water, and are an agglomeration of semi-permanent structures built on a platform raised on piles. Many are permeated by the penetrating odour of pigs, which are kept in almost every house, and all reek of drying fish, and of decaying offal generally. Most of the houses are constructed on a frame-work of mangrove wood, with floors of spilt *nibong* (*Oncosperma filamentosa*) or sometimes wooden boards, and with walls and roofs of the leaves of the *nipah* palm (*Nipa fruticans*). On the waterfront are thickly berthed the scores of small sailing vessels comprising the fishing fleet, which is left high and dry at low water. Mention should also be made of the curious "*Orang Selêtar*", an aboriginal race inhabiting parts of the swamps of South Johore and Singapore. These people live a miserable existence, subsisting on such fish and shell fish as they can catch and gather without venturing more than a few yards from their boats.

(*f*) HEALTH.

Contrary to what might be expected the mangrove forests, although generally swarming day and night with mosquitoes and sand-flies, are surprisingly healthy, the most malarious spots on the whole of the west coast being those where the beach is sandy. Fever-carrying Anopheles are said to be absent, and the Chinese fishermen, who take no special precautions, suffer rather less from malaria than is usual in inland districts. At certain seasons, mosquitoes of any kind are entirely absent from particular localities during the day, and not more than ordinarily troublesome at night.

(*g*) FAUNA.

Animals are to be found in abundance, although little is seen of them owing to the density of the tree growth. *Kera* monkeys (*Macacus irus*) are common on the fringes of the forest, where they find plenty of small shell-fish and crabs and do a certain amount of damage by mischievously uprooting newly fallen or planted seedlings. In the drier areas the gollywog-like *lotong* (*Semnopithecus*) often replaces the *kera*. The slow loris or *kongkang* (*Nycticebus tardigradus*) is not uncommon, but as his maximum speed is a slow crawl he requires to be an adept at concealment and is, therefore, seldom noticed. The monkeys are preyed on by the crocodiles, which sun themselves on the mud-banks while the tide is rising; though in rivers where the latter are frequently hunted they are rarely to be seen during the daylight hours. Inside are found wild-pig, bears, tigers, *bakau* snakes (*Lachesis*), monitor lizards (*Hydrosaurus*) often erroneously called iguanas, and otters; though none of the first three in sufficient numbers to excite notice. Tigers have been seen swimming the channels between the islands, to which they are doubtless attracted by the pigs, and there have (though not for some years) been several instances of man-eaters carrying off Chinese woodcutters and completely disorganising work in the forest until they have left the neighbourhood or been destroyed. Generally speaking, however, neither tigers nor crocodiles are given much thought by the inhabitants of the swamps which, as residential areas, are by no means as black as they are usually painted.

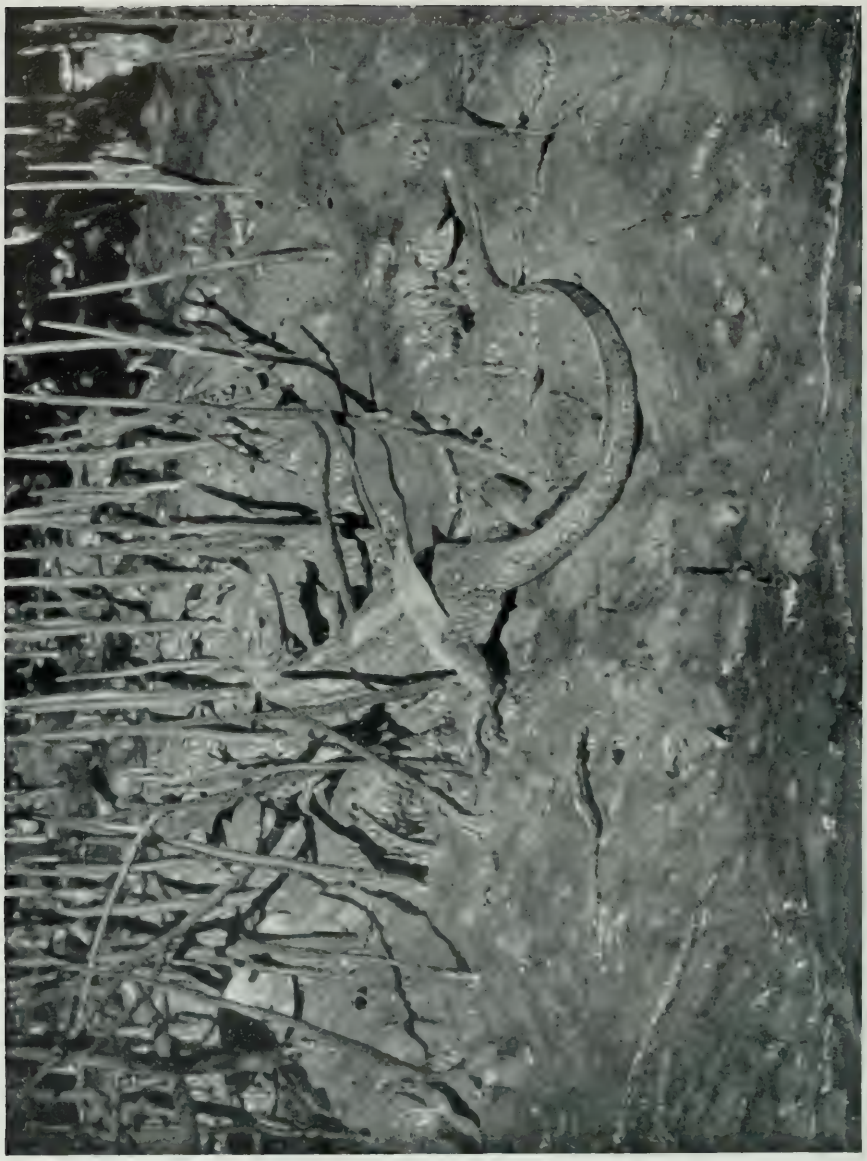
Flying foxes (*Pteropus*) sometimes form large colonies in the trees and raid the neighbouring orchards in the night. Mr. Boswell, Assistant Conservator of Forests, estimated that not less than 30,000 of these animals flew over his launch one evening within an hour. Amongst birds may be mentioned green pigeon, sea pigeon, snippets, king-fishers, fish eagles, gulls, terns, adjutant birds, red-shanks, egrets, and curlew, the last named teeming in and around Pulau Tengar, a small island in the neighbourhood of Port Swettenham.

Everywhere are to be seen countless small and often brightly coloured crabs, the most noticable being the fiddlers, which have one of their claws monstrously enlarged and coloured vivid blue or red. These dart in and out of holes in the mud, or hide in the ventilating chimneys of the *hudang ketak* (*Thalassina sp?*) a burrowing prawn that is common in the drier areas and which frequently does much damage to the bunds around coconut plantations. These crustaceans appear to perform in the mangrove



Photo by V. G. Bell.

4. A basking crocodile.



5. A monitor lizard amongst air-roots of Avicennia.



6. A fish-eating mud snake. *Photo by V. G. Bell.*



7. Mud fish, TEMBAKOL.

swamps the functions carried out by earth-worms and insects in inland forests, and at least one species of crab (*Sesarma taeniolata*) is responsible for damage to seedlings equivalent to that caused by rodents elsewhere. Further particulars of this pest will be found on page 150.

In and near the streams, where the mud is soft, large numbers of amphibious mud-fish or gobies (*Boliopthalmus* and *Periopthalmus*) desport themselves and even chase each other up and down the more accessible stilt roots to a height of two or three feet. Excellent oysters are obtainable in some of the creeks, whilst less appetising shell fish in the shape of *lokan* and *kerang* (cockles) are eagerly sought by the poorer classes of the community at low tide.

(*h*) General Characteristics.

In the mangrove belt the water is generally muddy and thick, though in some places at high tide, particularly where there is a sandy bottom, it may be green and clear as in the open sea. The foliage is generally dense and of a shining dark green colour, except in the larger estuaries where the forest is usually fringed with the duller leaved Avicennias and Sonneratias, with their characteristic greyish or pale green somewhat straggling crowns. These are frequently illuminated at night by swarms of fireflies, a peculiarity which is recognised and has led to the preservation of these trees as an aid to navigation in the Kuantan river. Along the narrower waterways the stilt roots and germinating seedlings of *bakau kurap* (*Rhizophora mucronata*) crowd the banks and create a screen which gives the impression of impenetrability and has led to erroneous impressions of the abundance and hardihood of this species.

None of the mangroves grow to a great size, a typical mangrove forest from within having the appearance of a sturdy pole crop, often interspersed with large trees of an older generation. In comparatively newly formed forest these are often *perepat* (*Sonneratia Griffithii*), whilst *tumu* (*Bruguiera gymnorhiza*) is typical of the older swamps. Both of these may reach a height of 100 feet or more, and a girth of 8 feet; the other species do not as a rule exceed 80 and 5 feet respectively, except in old unworked forests on the landward edge of the mangrove. The canopy is usually complete and advance growth in consequence scanty. In the drier forest an undergrowth of *piai* fern (*Acrostichum aureum*), growing usually on hummocks of earth formed by prawns, and thriving extraordinarily in open places, is almost always present. The most noteworthy features of the mangrove forests, apart from the strangeness of their situation, are, however, the paucity of the

species comprising them, the stilt roots of the rhizophoras, the clusters of blind root suckers, or pneumatophores, protruding from the ground in such numbers as to be an impediment to walking, the curious adaption to environment by which the seeds of the principal genera germinate on the tree*, and the large percentage of trees with noticeably lenticellate bark.

* Guppy (21) does not agree that this is an adaptation. He regards vivipary as a survival from an age in which this form of reproduction was the rule. See page 20.

Chapter II.

THE FLORA; ITS GENERAL CHARACTERISTICS.

(*a*) General.

The mangrove forests are evergreen. The paucity of species occurring in them is due to the peculiar conditions of their existence, few plants being able to flourish in saline mud and to withstand frequent inundation by sea water. They also differ from the inland forests of the peninsula in that certain species are practically gregarious over considerable areas. The flora is confined almost entirely to the four natural orders, Rhizophoraceae, Verbenaceae, Lythraceae, and Meliaceae, of which the first is by far the most important. Other orders are sparingly represented, chiefly in situations where the limits of the mangrove are not sharply defined.

An attempt is made in this chapter to give a general idea of the principal forest characteristics of the different species, so that forest officers and others with no deep botanical knowledge may be able to recognise them in their natural surroundings. The descriptions of orders and genera are of local and not necessarily of general application. No attempt is made to give minute technical details, which will be found in Chapter III. Opportunity is taken to correct some of the more flagrant misstatements into which a number of writers have been tempted by the somewhat unorthodox and apparently paradoxical behaviour of the species that go to make up the mangrove.

It may be stated with certainty that all the Rhizophoraceae, with the possible exception of Kandelia, are capable of growing into trees if the conditions are sufficiently favourable. Moreover, the majority of them attain a much larger size than is credited to them by most botanical writers, who ordinarily only visit the more accessible areas over which work has been going on for many years and where the larger trees have either been removed or have died from old age or exposure. The dimensions given are those attained in the Federated Malay States, and do not hold good everywhere. Thus, the Rhizophoras are said by Siamese forest officers to be generally larger in Siam than in this country, possibly because the forests here have been heavily worked for some years. It is stated by Schneider in *Commercial Woods of the Philippines** that *R. mucronata* forms a larger tree than *R. conjugata*, but the converse is the case here. *Lumnitzera coccinea* is frequently described as a small shrub, a mistake that arises from the superficial resemblance

* P. I. Bureau of Forestry; *Bulletin* No. 14.

between young Lumnitzera and Aegiceras, the latter being often erroneously called *teruntum* by Malays. Though *Lumnitzera racemosa* does not form much more than a shrub, *L. coccinea* is one of the largest trees of the mangrove swamps, attaining a height of well over 100 feet and a girth of 8 feet or more.

Making full allowance for differences of opinion and faulty observations there is, no doubt, great variation in the distribution of the species within comparatively narrow geographical limits. The notes of occurrence in this chapter will, therefore, often be found to disagree with records from other parts of the world.

(*b*) PECULIARITIES OF STRUCTURE.

(*i*) *Germination and Vivipary.*

Vivipary is a common phenomenon amongst the species inhabiting the mangrove. Some authorities regard this peculiarity as an adaptation, but others, notably Guppy (21) consider that it is cvipary that is the result of adaptation to environment.

"It is suggested that the viviparous habit may have been the rule under the uniform climatic conditions of early geological periods and that with the differentiation of climates that marked the emergence and extension of the continental areas the viviparous habit has been lost, except in those regions of the mangrove-swamps which to some extent retain the climatic conditions once general over the globe. With differentiation of climate the true seed-stage with its varying rest-periods has been developed."

Warming (51) summarises the different degrees of vivipary amongst mangrove as follow:—

"(*a*) In *Aegiceras* the embryo emerges from the seed but remains inside the fruit; it has a large stem and is green.

(*b*) In *Avicennia* the endosperm and subsequently the embryo emerge from the seed and lie uncovered within the chamber of the ovary. The embryo is green and obtains food from the parent-plant by means of a long, repeatedly branched, hypha like haustorial cell, which traverses the placenta.

(*c*) In *Rhizophora* and allied genera (*Bruguiera* and *Ceriops*) the embryo grows not only out of the seed, but also out of the fruit, and projects from the latter in the form of a green seedling displaying the hypocotyl and root, which in some species exceed one third of a metre* in length; "like long, green pods the full formed seedlings hang down from the branches." The cotyledons serve as a haustorium, sucking fruit from the parent plant. Finally, the seedling breaks loose from the cotyledons (*Rhizophora* has only one cotyledon), which remain behind inside the fruit and shrivel with it†; it falls into the water or mud; its club-shape and pointed root-end adapt it to pierce the mud, into which it rapidly thrusts lateral roots that had previously been initiated. If the seedling does not succeed in fixing itself, it floats and may strike root on some distant shore; in this way the species is provided with means of dispersal by water. Vivipary is most pronounced in those Rhizophoraceae that grow in very deep water and very soft soil, and is obviously of great advantage to the species.

We must regard as adaptations to the environment the green nature of the infant-plant, and the presence of anchoring organs which take the form of upwardly-directed bristles on the seedling, or (in *Avicennia*, *Aegiceras*, *Sonneratia* and *Rhizophora*) of lateral roots which are already prepared and can rapidly burst out."

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* The radicle of *Rhizophora mucronata* may exceed a metre in length. Ed.

† The fruit of Bruguiera remains attached to the seedling for some time after falling. Ed.

(*ii*) *Xerophytic Structure.*

Reference has already been made to the xerophytic character of the mangrove flora. For the following description of the different adaptations I am again indebted to Warming (51):

"The constituent species of the mangrove, with one exception, are shrubs and trees.[1] Despite the circumstance that these plants grow in inundated muddy soil, their vegetative shoots display a number of structural features that occur in plants adapted to withstand drought. The features in question are the following:—

(*a*) The leaves are thick, coriaceous or somewhat fleshy, and entire: Sonneratia, Lumnitzera, Carapa, Rhizophora, Avicennia.

(*b*) The **epidermis** is thick-walled and strongly cutinized; the leaves are often very glossy: *Rhizophora Mangle.*[2]

(*c*) Various organs of the leaves of mangrove-plants have been interpreted by Areschoug as **hydathodes.** In the mangrove on the coast of Siam, Schmidt found that glands on the upper face of the leaves of *Aegiceras corniculatum*[3] excrete salt. During the night the salt-crystals absorb water from the atmosphere and deliquesce, but during the morning the water again evaporates and the salt crystallizes out. In no other species was the excretion of salt found by Schmidt.

(*d*) **Stomata** are often sunk beneath the general surface, and urn-shaped anterior chambers are general.

(*e*) **Aqueous tissue** is always present, and sometimes massive. In *Rhizophora mucronata*, the older leaves, which no longer assimilate, become thicker than they were in youth; this is caused by an enlargement of the aqueous tissue: thus the leaf changes its function.

(*f*) The **mesophyll** is almost devoid of intercellular spaces, and the palisade tissue is the sole or main chlorenchyma: Sonneratia, Lumnitzera, and others.

(*g*) The **nerve-ends** dilate into water-storing tracheids: Bruguiera, Avicennia, Ceriops, and others.

(*h*) **Long stone-cells** or bast-like mechanical cells are lodged between the pallisade cells in Rhizophora, Sonneratia, and Carapa, and in the pith of Rhizophora.

(*i*) **Mucilage-cells** occur in species of Sonneratia, Rhizophora, and some others.

(*j*) Some species are strongly and densely clothed with **hairs**: Avicennia.

(*k*) The leaves assume a **profile-lie**[4] and consequently acquire isolateral structure: Sonneratia, Lumnitzera, Ceriops, also Laguncularia.[5]

The cause of this xerophytic structure is to be sought in the physiologically dry soil, and in the position of the leaves, which are raised free into the air[6] and are exposed to intense tropical light, high temperature, and wind."

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[1] The exception referred to is *Acanthus ilicifolius.* There are however, others, *e.g. Acanthus ebracteatus, Pluchea indica,* and *Acrostichum aureum.* An enumeration of the principal and subsidiary Malayan species will be found on page 22. Ed.

[2] A western species; true also of local Rhizophoras. Ed.

[3] *Aegiceras majus.*

[4] The author's meaning is slightly obscure. Presumably he means that the leaves of these plants present their edges to the light, and that both surfaces are more or less equally capable of reacting to the effects of light. Ed.

[5] A western genus, near Lumnitzera (*Combretaceae*). Ed.

[6] *i.e.*, exposing the maximum number of leaves with the minimum degree of mutual shade. Ed.

(*c*) ENUMERATION OF THE SPECIES.

Excluding herbs, climbers, epiphytes, and the lower forms of plant life, which are not dealt with here, the species typical of the mangrove forests are the following:—

PRINCIPAL SPECIES.

I. Rhizophoraceæ.

Botanical name.	*Malay name.*
Rhizophora mucronata Lam.	Bakau kurap, Belukap.
„ conjugata L.	Bakau minyak, B. tandok, Akik.
Bruguiera gymnorhiza Lam.	Tumu.
„ eriopetala W. & A.	Tumu puteh, Mata buaya.
„ caryophylloides Bl.	Berus, Burus.
„ parviflora W. & A.	Lenggadai.
Ceriops Candolleana Arn.	Tengar.
Kandelia Rheedii W. & A.	Berus-berus, Pisang-pisang.

II. Lythraceæ.

Sonneratia acida Linn. f.	Berembang, Pedada.
„ alba Smith.	Gedabu.
„ Griffithii Kurz.	Perepat.

III. Verbenaceæ.

Avicennia officinalis L.	Api-api puteh, Ludat.
„ intermedia Griff.	Api-api puteh, A. mêrah.
„ alba Bl.	Api-api hitam.
„ lanata Ridl.	Api-api puteh, A. berbulu.

IV. Meliaceæ.

Carapa obovata Bl.	Nyireh bunga, N. hudang.
„ moluccensis Lam.	Nyireh batu.

SUBSIDIARY SPECIES.

V. Malvaceæ.

Hibiscus tiliaceus Linn. Thespesia populnea Corr.	Baru, Waru, Bebaru.

VI. Sterculiaceæ.

Heritiera littoralis L.	Dungun.

VII. Tiliaceæ.

Brownlowia lanceolata Benth.	Durian laut.
„ Riedelii Hemsl.[1]	Walan? (*Uncertain*).

VIII. Combretaceæ.

Lumnitzera coccinea Wight.	Teruntum bunga mêrah.
„ racemosa Willd.	T. bunga puteh, Sesup.

[1] Found on the east coast;—rare or absent in the west.

XI. Leguminosæ.	
Intsia retusa (Colebr.) O.K.	Ipil.
Derris uliginosa Benth.	Setui, Salang.
X. Euphorbiaceæ.	
Excœcaria Agallocha L.	Buta-buta, Bebuta.
XI. Rubiaceæ.	
Scyphiphora hydrophyllacea Gærtn.	Chingam, Chengam.
XII. Compositæ.	
Pluchea indica Lam.	Beluntas.
XIII. Myrsinaceæ.	
Aegiceras majus Gærtn.	Kachang-kachang.
XIV. Apocynaceæ.	
Cerbera lactaria Ham.	Pong-pong. *Often erroneously called* Buta-buta.
„ Odollam Gærtn.	
XV. Acanthaceæ.	
Acanthus ebracteatus Vahl.	Jeruju hitam.
„ ilicifolius L.	Jeruju puteh.
XVI. Palmæ.	
Oncosperma filamentosa Bl.	Nibong.
Nipa fruticans Wurmb.	Nipah.
Dæmonorops leptopus Mart.	Rotan bakau.
XVII. Coniferæ.	
Podocarpus polystachyus R. Br.[1]	Jati laut.
XVIII. Cycadaceæ.	
Cycas Rumphii Miq.[1]	Paku laut, P. gajah.
XIX. Filices.	
Acrostichum aureum L.	Piai lasa, P. raya, Larat.

(*d*) Forest Characteristics.

(*i*) RHIZOPHORACEAE.

The Rhizophoraceæ are readily distinguishable by their obviously viviparous seeds which, when ready to fall, are a conspicuous feature of even very young trees. The pointed radicle protrudes downwards from the apex of the fruit and, when fully developed, either detaches itself with the plumule from the cotyledon, leaving the latter in the fruit attached to the tree (as in Rhizophora) or it does not become detached from the fruit until some time after the whole thing has fallen, (as with all species of Bruguiera). This body, which actually consists of a complete plant

(1) Found on the east coast;—rare or absent in the west.

RHIZOPHORACEAE.

Viviparous Fruits.



Scale approximately 1/5.

1. Rhizophora mucronata.
2. „ conjugata.
3. Ceriops Candolleana.
4. Kandelia Rheedii.
5. Bruguiera parviflora.
6. „ gymnorhiza.
7. „ eriopetala.
8. „ caryophylloides.

composed of plumule, hypocotyl, and radicle, is here more conveniently referred to as the seed. It is designed to fall vertically and to implant itself in the mud beneath the parent tree, though some of the Bruguieras are not so well adapted for this purpose and rely to a greater extent on water dispersal. The illustration on the opposite page enables a comparison between the various forms.

The Genus Rhizophora.

Of the four genera of Rhizophoraceæ, Rhizophora is the most important, frequently forming from seventy to ninety per cent of the growing stock. The rhizophoras are straight trees which, when growing in closed forest, have cylindrical boles and compact crowns. They may at once be recognised by their mucronate leaves and the peculiar stilt or flying-buttress roots which are produced very speedily from the part of the radicle remaining above ground after the seed has implanted itself in the mud, further roots springing from the stem, roots, and even branches, as the tree increases in size. The height of production, and the spread of the roots themselves, are influenced by the locality, trees growing in shallow soils or subject to very deep inundation producing the greatest mass and spread of roots.* It has been stated by Goebel (20) and others that the branching of these stilt roots is always the result of an injury to the tip of the original ones, an observation that is probably true of the branch or "columnar" roots but that does not apply to the real buttress roots, which continue to produce side branches long after they have established themselves in the mud and have become tough and woody. Kerner (26), doubtless impressed by the uselessness of such an appanage to an ærial organ, states that these ærial roots do not possess root caps, a somewhat unfortunate generalisation that is certainly untrue of the Eastern species, both of which produce conspicuous, black, hemispherical, root-caps which may be as large as the tip of the finger. The stilt roots are light brown, smooth, cylindrical, soft, and easily broken by the fingers when young, but after entering the ground they become woody and exceedingly tough, easily supporting the weight of a man: in fact they are often so numerous and thickly intermingled that one is forced to make one's way along them some feet above the surface of the mud. Very old stilt-roots have a rough bark and have lost to some extent their cylindrical form. Ultimately, as shown in the illustration on page 147, the stem of the tree stands clear of the ground, mounted on a more or less hemispherical group of stilts, which may be 20 feet or more

* See page 145.

in diameter. The original tap-root or lower portion of the stem gradually dies, being visible in the centre and often clear of the ground. It is frequently asserted that the stem is raised by the lengthening of the stilt roots, but this cannot be accepted without verification, and is not borne out by an examination of trees which have been measured for several years in sample plots. Schimper (47) considers it impossible.

One form of *R. conjugata*, commonly known as *akik*, produces ærial columnar roots from the branches. These are similar in all respects to stilt roots, except that they are vertical and frequently much branched. They rarely succeed in reaching and rooting in the ground, except in areas liable to frequent inundation, where periodical immersion helps to keep them alive. A similar habit is occasionally to be observed with *R. mucronata*, but with this species the roots are more sparingly produced and usually spring from the upper portion of the stem. This habit is commonest with trees growing close to the river bank and is rare in closed forest.

None of these aerial roots serve any regenerative purpose, and with all due respect to the *Encyclopaedia Britannica*, it can be stated, at any rate as far as Malaya is concerned, that the Rhizophoras do not reproduce themselves in the manner of the Banyan tree. It is however, recorded by Guppy (21) that the Fijian "*Selala*" (which he regards as one of the dimorphic forms of *R. mucronata*) never produces seeds and invariably regenerates itself in this way. Oliver (36) speaking of the radicle, says that "it grows to a length, sometimes, of several feet, reaching the mud, and throwing out branch-rootlets from its base before parting from the parent tree." Attention to this mistake is drawn by Kerner (26) who says on page 756:

> "It is, of course, true that the embryo grows out from the fruits while they are hanging on the branches, but they become detached and, falling with considerable velocity, bore into the mud by their lower thickened end. It never happens that one of these embryos *grows* down to the ground from the branch, and there is no doubt that the long roots, extending from the crown of the tree down to the mud, originate from the lower horizontal branches of the mangroves just like other columnar roots."

Confusion may have arisen in the minds of the early authors from the peculiar adaptation whereby the lateral roots are *initiated* in the radicle before the seedling parts company with the parent tree.

Another wonderful adaptation described by Haberlandt whereby the flying-buttress roots support the tree against wave action is mentioned elsewhere.* It may here be dismissed with the remark that the Rhizophoras do not normally grow where they are exposed to the direct action of the sea. A further example of the general inapplicability of this writer's observations is provided by the statement that *R. mucronata* generally forms upright trees, whilst *R. conjugata* creeps about all over the place.

Neither of the Rhizophoras produces kneed pneumatophores, which are such conspicuous features of the other genera belonging to this and some of the other families of mangrove plants.

The main differences between the two species are as follow:—

Rhizophora mucronata.	**Rhizophora conjugata.**
Bakau kurap, Bakau jangkar, Belukap.	*Bakau minyak, Bakau tandok, Bakau akik.*
Names:	
(*Specific*)—Refers to the very sharp terminal point (mucro) of the leaf.	Refers to the symmetrically paired flowers.
(*Vernacular*)—*Kurap* implies resemblance to the skin disease of that name and may refer either to the rough scaly bark or to the somewhat warty appearance of the radicle.	*Minyak* means oil or oily, and is possibly connected with the smooth and shining radicle. *Tandok* (horn) may refer to the smoothness and colour of the bark.
Occurrence.	
Gregarious, less frequently sporadic, near, and especially on, the banks of creeks; seldom more than a few chains from tidal water. Reaches its optimum development in inundation class 3 if deep and rich in humus; also found in inundation classes 2 and 4.†	Gregarious or sporadic throughout the mangrove area. Commoner than *R. mucronata*. At its best in inundation classes 3 and 4, where it frequently forms 90% of the crop.

* See page 125.
† See page 129.

Size.

Up to 90′ high and 4′ 6″ in girth above stilt roots.

Up to 100′ high and 7′ in girth above stilt roots, but generally a great deal smaller.

Bark.

Dark, almost black, with horizontal fissures almost completely encircling the stem; or reddish and scabrous, or tessellated like that of an old Scots Pine.

Grey, sometimes almost smooth; fissures vertical rather than horizontal, and never encircling the stem. In the case of *bakau tandok* bluish gray and covered with small reticulations.

Leaves.

Larger than those of any other of the mangroves; up to 8″ x 5″. Midrib green below. Lower surface covered with clearly visible small black dots. Set at a wider angle with the twig than those of *R. conjugata.*

About 6″ x 2½″; often smaller. Midrib pink below, or, in the case of *bakau tandok*, sometimes green. Black dots on lower surface minute, sometimes indistinct, or even obsolete. Set at a more acute angle with the twig than those of *R. mucronata.*

Inflorescence.

Lax; flowers white, 2 to 6, stalked; petals fleshy.

Stiff; flowers white, symmetrically paired, sessile; petals thin.

Fruit.

About 2½″ long; extruded radicle usually about 2′, but sometimes over 3′ long, tapering to a point, green, tuberculate, usually straight.

About 2″ long; extruded radicle seldom over 1′ long, bluntly pointed, green, tinged with red, smooth, shining, frequently curved.

Miscellaneous notes.

The form with the reddish bark appears to have a tendency to produce ærial roots from the branches and upper part of the stem, though these are neither so frequently nor so abundantly developed as in the case of *R. conjugata.*

The form known as *bakau akik*, which is frequently associated with that known as *bakau tandok*, commonly produces ærial roots from the branches.



8. BAKAU KURAP (*Rhizophora mucronata* Linn.); leaves, buds, and fruit.



9. BAKAU KURAP (*Rhizophora mucronata* Linn.); stem.

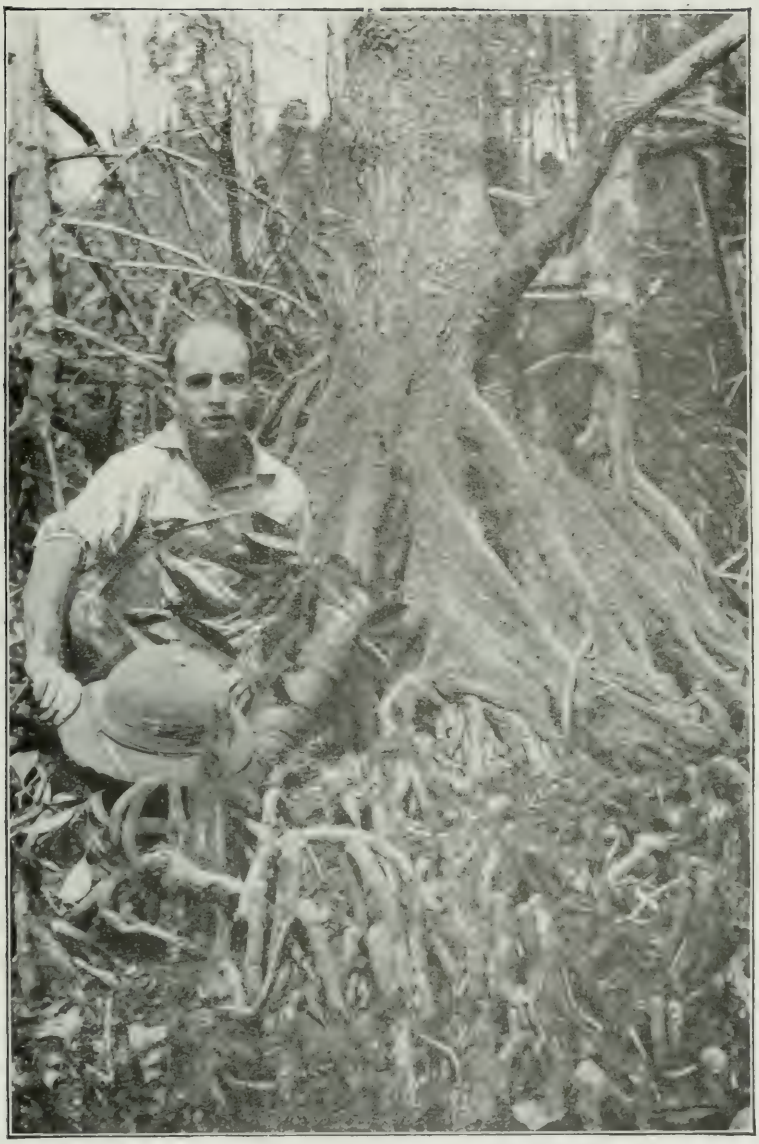


(2 m. squares)

10. BAKAU MINYAK (*Rhizophora conjugata* Linn.); leaves, buds, and fruit.



11. BAKAU MINYAK (*Rhizophora conjugata* Linn.) ; stem.



11(*a*). MATA BUAYA (*Bruguiera eriopetala* Wight.);
stem with aerial roots.



(2 in. squares)

12. TUMU (*Bruguiera gymnorhiza* Lam.); leaves and fruit.



13. MATA BUAYA (*Bruguiera eriopetala* Wight.); leaves, flowers, and fruit.



~~14. TUMU (*Bruguiera gymnorhiza* Lam.); stem and pneumatophores.~~

14. MATA BUAYA (*Bruguiera eriopetala* Wight.); note the lenticels on the buttresses, which distinguish this species from TUMU (*B. gymnorhiza* Lam.)



15. BERUS. (*Bruguiera caryophylloides* Bl.); leaves, flowers, and fruit.



16. BERUS (*Bruguiera caryophylloides* Bl.) ; stem and pneumatophores.



17. LENGGADAI (*Bruguiera parviflora* Wight.); immature fruit and flowers.



18. LENGGADAI (*Bruguiera Parviflora* Wight.); stem.

The Genus Bruguiera.

The Bruguieras differ from the Rhizophoras by the general absence (except sometimes in the case of *B. eriopetala*) of stilt roots, and the presence of kneed pneumatophores, which project in abundance above the surface of the mud. The bark of most species is conspicuously lenticellate, particularly when young. The fruit remains attached to the radicle, the calyx lobes assisting to anchor the seedling in the mud. Skene (48) describes the buttresses as prop roots, like thick blades, slanting away from the base of the tree into the mud, but this description though not inapt as regards certain individual trees is not in keeping with the orthodox appearance of the average Malayan Bruguiera forest, a pure stand of *B. gymnorhiza* with its pneumatophores screened by *piai* fern suggesting a well grown oak wood. (See illustration on page 148).

Generally speaking, the Bruguieras grow in less frequently inundated situations than the Rhizophoras, and rely to a greater extent (*B. caryophylloides* probably almost entirely) on distribution by surface water following heavy rains. *Bruguiera parviflora* (*lenggadai*) is less discriminating than any other mangrove species, and forms pure crops under a great variety of conditions.

Some of the vernacular names current in British North Borneo and recorded by Foxworthy and Matthews (17) are similar to those used locally, but do not apply to the same trees. Thus, the Bornean names of both *B. gymnorhiza* and *B. eriopetala* are given as *lenggadai* or *pututan*, whilst *B. parviflora* is there called *B'eus*.

Four species are represented in the swamps. The following comparative statement emphasises the principal differences:—

Bruguiera gymnorhiza. *Tumu, T. mèrah.*	**Bruguiera eriopetala.** *Tumu puteh, Mata buaya.*
Names:	
(*Specific*)—Literally "naked roots", but not particularly apt. Would be better applied to the rhizophoras or to *B. eriopetala.*	Refers to the hairy edges of the petals, though those of *B. gymnorhiza* are equally hairy. (Compare p. 110).
(*Vernacular*)—*Tumu* has no definite meaning. The adjective "*mêrah*" (red) is sometimes used to distinguish this species from the next, and refers to the colour of the calyx.	The adjective "*puteh*" (white) distinguishes the calyx from that of the preceding species. *Mata buaya* means "crocodiles' eyes," and refers to the conspicuous lenticels that are produced on the stems of old trees.
Occurrence.	
As a rule on somewhat dry well aerated soil in inundation classes 4 and 5 towards the landward side of the mangrove belt. In the interior of islands it is occasionally pure but more often associated with *Rhizophora conjugata.* Sporadic in wet soil in inundation class 3. Never on the sea face except following erosion. Seedlings not plentiful near parent trees.	In similar situations to the foregoing but generally preferring wetter soils in association with *B. caryophylloides* and *B. parviflora.*
Size.	
One of the largest trees of the mangrove swamps, up to 120 feet high and 8′ in girth above the buttresses.	Rather smaller than the preceding species; up to 100′ high and 6′ in girth above buttresses.
Stem.	
Normally buttressed.	Sometimes with stilt roots; usually normally buttressed.

Bruguiera caryophylloides. *Berus, Burus, Bakau puteh.*	**Bruguiera parviflora.** *Lenggadai, Lenggadis.*
Names:	
(*Specific*)—Literally "claw like," from the reflexed calyx lobes.	Refers to small flowers.
(*Vernacular*)—*Bakau puteh* means "white mangrove" possibly from the light colour of the stem. The other names have no independent meaning.	The name *lenggadai* and its variants have no independent meaning.
Occurrence.	
Essentially gregarious in inundation class 4 on stiff clay immediately behind Avicennia on the sea face; less frequently sporadic in association with the foregoing and following species. Gives way to other species in better drained soils, existing gregariously by virtue of its ability to grow in newly formed soils unsuitable to other mangrove forms.	Essentially an opportunist species, and therefore occurring under a variety of conditions. At its best in mixture with Rhizophora in inundation class 3. Occasionally forms pure stands in classes 3 and 4, and increases as a result of exploitation of immature areas.
Size.	
Rarely more than 70′ high and 3′ 6″ in girth at breast height. Larger trees have been recorded, but are unusual.	Up to 70 feet high and 3′ in girth, but generally less. Attains its largest dimensions in mixture with *Rhizophora conjugata.*
Stem.	
Abruptly or shortly buttressed.	Normally buttressed.

B. gymnorhiza—(*Contd*).

Bark.

Lenticellate when young. Deeply fissured, thick, brown or almost black without noticeable lenticels when old.

Twigs.

Green, usually tinged with red; stipular scars broad, dark brown, prominent, and markedly corrugated.

Leaves.

6″—7″ x 2″—3″; petiole generally over 1¼″ long; elliptic acute; dark green.

Inflorescence.

Flowers solitary; calyx about 1¾″ long, scarlet, lobes 12 to 14, not reflexed.

Fruit.

Enclosed in calyx; extruded radicle cigar-shaped, ribbed, up to 8″ long but generally smaller, bronze or green, stout, smooth. Calyx falls with fruit but soon becomes detached.

Miscellaneous notes.

Brown and Fischer (6) state that the radicle is cylindrical and from 30 to 60 centimetres in length. Nothing approaching this size has been observed in Malaya. As these authors use the name *B. conjugata* it is suggested that confusion may have arisen with the fruits of *Rhizophora conjugata*, which would fit this description.

B. eriopetala—(*Contd*).

Resembles the preceding species; but is more lenticellate and rather paler. Old stems with conspicuous pale brown lenticels up to an inch or more in diameter.

Green, occasionally tinged with red; stipular scars rather broad, brown, prominent, not markedly corrugated.

4″—5″ x 1¾″—2½″; petiole about 1″ long; elliptic acute, dark green.

Flowers usually in threes; calyx about 1″ long, yellowish or pinkish, lobes 9—11, slightly reflexed.

Enclosed in calyx; extruded radicle cigar-shaped, stout, a little rough to the touch, green, terete, up to 6″ long. Calyx falls with fruit but soon becomes detached.

A very variable species with many intermediate characters between the preceding and following. It is suggested that it may possibly be a cross between them.

B. caryophylloides—(*Contd*).	**B. parviflora**—(*Contd*).
Bark.	
Grey, lenticellate, especially when young; thin, smooth or only slightly rough. Blaze smells strongly of crushed pea-pods.	Smooth, grey, blotched with white; inconspicuously lenticellate.
Twigs.	
Green; stipular scars fine, brown or grey, with darker upper edge. Young shoots have a salty, leguminous, taste.	Green or yellowish; stipular scars fine, almost black. Young shoots have a distinctly astringent taste.
Leaves.	
About 4″ x 1¾″; petiole about 1″ long; elliptic acute, dark green.	About 4½″ x 1¼″; petiole less than 1 inch long, narrower than the preceding species, often yellowish.
Inflorescence.	
Flowers in twos and threes, rarely single; calyx about ½″ long, green, lobes 7—9, reflexed.	Flowers in groups of 2 to 5, about ½″ long; calyx tube trumpet shaped surmounted by small tooth-like lobes.
Fruit.	
Enclosed in calyx; extruded radicle bowed, about as thick as a lead pencil, a little rough to the touch, green or bronzed, terete, up to 6″ long. Calyx falls with fruit but almost immediately becomes detached.	Enclosed in calyx; extruded radicle straight, thinner than a pencil, smooth, green, terete, up to 8″ long. Calyx falls with fruit and remains attached even after the development of the plumule, which grows through the base of the tube.
Miscellaneous notes.	
A slow grower, particularly where (as is usually the case) regeneration has been prolific.	A short-lived species. Mature trees (particularly in pure stands) frequently suffer from wind-break preceded by insect attack.

The Genus Ceriops.

This genus is represented in Malaya by a single species, forming medium sized trees chiefly distinguishable by their fawn coloured lenticellate bark, and their horizontally branched, somewhat tufted crowns. According to Brandis (4) the branches send down aerial roots, a peculiarity that has not been recorded in this country, but which is corroborated by an anonymous writer in the Siamese "*Record*" for January, 1925, who states that in Siam the tree does not develop stilt roots, but that it is frequently anchored to the ground by aerial roots developed from the branches. Becking and Berger (1) and Warming (51) credit the species with stilt roots, but, though many trees have been examined here, the most that can be said is that the fluted buttressess are sometimes suggestive of those organs.

A small Ceriops destitute of fruit or flowers might, at first sight, be mistaken for Scyphiphora; but the latter is always thickly bushy and has shorter, rounder leaves, whose length is much less than twice their width, whilst the two terminal leaves are covered with a sticky substance and are closely adherent. The leaf buds of Ceriops, on the other hand, are pointed and enclosed by the stipules.

King and Gamble (27) include *C. Roxburghiana* amongst the Malayan species, but its occurrence appears to have been assumed without the evidence of collected specimens.

Ceriops Candolleana. *Tengar.*

Name. The derivation of the generic name is obscure.

The Malay name has no definite meaning.

Occurrence. Usually sporadic; occasionally gregarious on well drained soils not far from the sea. Much commoner in Selangor than in Perak. Mature trees are uncommon locally because the bark is in great demand amongst fishermen, who do not give it much chance to grow to any great size.

Size. Not, as stated by most authorities, a shrub or dwarf tree, but a fair sized tree up to 80′ x 4½′, degenerating in the open and in unsuitable soils into a stunted bush.

Stem. With fluted buttresses to a height of 3 feet or more, moderately straight, rather apt to fork.

Bark. Fawn, often discoloured, smooth, inclined to flake, occasionally scabrous, with conspicuous darker coloured lenticels.

Leaves. Almost exactly twice as long as wide, obovate, blunt or slightly retuse, 4″ x 2″ or less.

Inflorescence. Insignificant, pedunculate, branched; flowers on short stalks in clusters of 4 to 6.



19. TENGAR (*Ceriops Candolleana* Arn.); leaves and fruit.



20. TENGAR (*Ceriops Candolleana* Arn.); stem.

Ceriops Candolleana.—(*Contd.*)

Fruit. Inverted pear-shaped, 1″ long.

Radicle. Rather more than a foot in length when ready to fall, slender at the base, thickened towards the apex, sharply pointed, grooved, warty, dark green. Frequently turns brown and dies on the tree. Seed produced in abundance.

Pneumatophores. Rounded, scaly, reddish, like those of Bruguiera.

The Genus Kandelia.

Represented by a single species of little importance, distinguishable from Ceriops by its smooth shining radicle, large flowers, and elongated oblong leaves.

Kandelia Rheedii. *Berus-berus, Pisang-pisang, Pulut-pulut.*

Name. The scientific names have no descriptive value. The first Malay name suggests a resemblance to *berus* (*Bruguiera caryophylloides*). *Pisang-pisang* is commonly applied to anonaceous plants having fruit clusters resembling small bunches of bananas. It is likely that Kandelia has been so named on account of its habit of occasionally producing several radicles from a single fruit, or possibly because of a fancied resemblance of its flowers to those of some of the anonaceous species.

Occurrence. Sporadic, and limited to the banks of tidal rivers. Reported from various parts of Selangor, and not uncommon on a number of rivers on the east coast. Not seen in Perak.

Size. A small tree rarely as much as 20′ high.

Stem. Conically thickened at the base, but not truly buttressed. The base of the stem is covered with flaky bark and presumably performs the same functions as the pneumatophores of the other members of the family.

Bark. Thin, smooth, reddish or greyish-brown, sometimes mottled with white and bearing tubercular lenticels. Blaze pink.

Leaves. Margins reflexed; 3″—5″ x 1″—1½″; leaf buds twisted.

Inflorescence. Dichotomously branched with a few flowers on stalks 1″ to 2″ long. Flowers white, showy.

Fruit. Inverted pear shaped, about 1″ long.

Radicle. Fusiform (spindle-shaped), very sharp pointed, up to 16 inches long when ready to fall, green, smooth, terete, shining. Two or more radicles (5 have been recorded) are not infrequently formed on one fruit.

Pneumatophores. Absent; see under "stem."

(*ii*) LYTHRACEAE.

The Genus Sonneratia.

Considerable confusion exists in botanical works with regard to the nomenclature of the different species. There is, however, no difficulty in distinguishing between the three forms which occur in British Malaya, all of which produce large showy flowers with an abundance of globular anthers on long thread-like filaments, and conspicuous many-seeded fruit somewhat suggestive of the closely related pomegranate. Pointed pneumatophores are common to all species, varying in size from asparagus-like projections closely resembling the corresponding organs of Avicennia, to structures similar to inverted parsnips, which are said by Foxworthy (13) to attain a height of a metre or more and a diameter at the base of several inches. Such large ones have not been reported in Malaya. Except where erosion has uncovered them these pneumatophores are usually covered with mud, so that only the comparatively small tips are visible.

Although there are superficial resemblances between young Sonneratias and Avicennias, which are heightened by the part that both of them play as pioneers in the formation of the mangrove swamps, the two can be readily distinguished by the green undersides of the leaves of the former, as compared with the pale undersides of the latter. *Sonneratia acida* is, moreover, characterised by the purple colour of the midrib and leaf base.

The chief differences between the species are as follow:—

	Sonneratia acida. *Berembang, Pedada.*	**Sonneratia alba.** *Gedabu.*	**Sonneratia Griffithii.** *Perepat.*
Names:			
(*Specific*)—From the acid fruits.		From the white flowers, though this character is not peculiar to this species.	No descriptive value.
(*Vernacular*)—No particular significance.		No particular significance.	No particular significance.
Occurrence.			
	Sporadic on or near the banks of tidal streams in inundation classes 3 and 4. If on the sea face always within the influence of a river. Associated with *Avicennia alba.* Common.	Sporadic at some distance from the water, well away from the sea in inundation class 4. Prefers a somewhat sandy soil. Not common.	Gregarious as a pioneer species in sheltered situations where mud is soft and deep. Often associated with *Rhizophora mucronata.* The commonest species.



(2 in. squares)

21. BERUS-~~BURUS~~ BERUS (*Kandelia Rheedii* Wight.); leaves and fruit.



(2 in. squares)

22. BEREMBANG (*Sonneratia acida* Linn.); leaves, flower, and fruit.



(2 in. squares)

23. GEDABU (*Sonneratia alba* Smith.); leaves, flower, and fruit.



24. PEREPAT (*Sonneratia Griffithii* Kurz); leaves, flower, and fruit.



25. PEREPAT (*Sonneratia Griffithii* Kurz.); Stem and pneumatophores.

Sonneratia acida—(*Contd.*)	**Sonneratia alba**—(*Contd.*)	**Sonneratia Griffithii**—(*Contd.*)
Size. Up to 70′ x 5′ but usually smaller. Rarely forms a well-shaped tree.	Specimens have been seen (in Perak) up to 80′ high and 6′ in girth, but the tree is usually very much smaller.	Up to 120′ high and 7′ or more in girth. One of the largest trees in the mangrove.
Stem. Crooked, bole rarely straight, not buttressed.	Usually contorted, rarely straight, often bifurcated, not buttressed.	Often contorted but where conditions are favourable tall and cylindrical with little taper and no buttresses.
Crown. Open, spreading; twigs pendulous.	Dense, branching low down on the stem; twigs stiff.	Narrow; main branches short; twigs stiff.
Bark. Smooth, grey, lenticellate when young; light brown, irregularly fissured when old. Inner bark laminated; blaze watery; exposed wood light in colour.	As for *S. Griffithii*, but rather rougher and grey rather than brown.	Fissured; brownish, like oak bark when old. Inner bark pinkish, not noticeably laminated; blaze not watery; exposed wood yellowish.
Leaves. Lanceolate; sessile or nearly so; base of midrib crimson.	Orbicular or broadly ovate with rounded base and short petiole; dark green; surface a little corrugated.	Obovate, tapering to base, with short petiole.
Flowers. Usually solitary; purple; sepals 6; petals 6.	Generally in twos or threes; white; sepals 6 to 8; petals present or absent.	Usually solitary; white; sepals 6 to 8; petals present or absent.
Fruit. Up to 3″ across when ripe; dark green and depressed above, with the consistency of an unripe pear; fruiting calyx concave below; style persistent and conically thickened at the base. Edible, but astringent.	Up to 2½″ across when ripe; yellowish; flattened above and below, but more globular than *S. acida*; turgid, fleshy; fruiting calyx ribbed, rugose; sepals embracing base of fruit; style persistent, not thickened at the base. Edible with quince-like flavour.	2″ or less across when ripe; bright green, hard, almost globular, but flattened or depressed above; fruiting calyx obconical, obscurely ribbed, smooth, sepals spreading, purple inside, markedly wider than the fruit; style persistent, thickened at the base. Not edible.
Pneumatophores. Do not ordinarily attain such a large size as those of *S. Griffithii*, but similar in shape and texture.	Similar to those of *S. Griffithii*, but darker and covered with scaly bark.	Vary in size and shape from that of an asparagus shoot to an inverted horse-radish, reaching largest dimensions where tree grows sporadically in shade on sandy soil. Small pneumatophores almost indistinguishable from those of Avicennia.

(*iii*) VERBENACEAE.

The Genus Avicennia.

Five species of this genus have been described by Ridley (42), but only four have been identified in the local forests. Until quite recently, most botanists were content to regard all these as forms or varieties of one, or at most two, very variable species, in spite of the recognition by independent observers of differences that are undoubtedly wide and definitely hereditary. This matter is, however, discussed in more detail in Chapter III.

The Avicennias are chiefly recognisable by their bushy crowns, which frequently clothe the stems almost to the ground, for even where they grow gregariously they naturally adopt such a wide spacing that self-pruning and the development of clear boles can only follow as the result of assistance from other species in the undergrowth. They are essentially light-demanders, and are incapable of regenerating themselves in even moderate shade. Their chief function is to act as pioneers and nurses to more shade-bearing species, with which they can exist only so long as they can keep their crowns dominant. It is unusual, therefore, for any of the species to predominate in any but young and freshly formed forest where the soil is still too raw for other forms. They can, however, and do reach their maximum development as isolated specimens in older formations, such as the banks of streams and sides of roads, where they can get the light that is essential to them.

All are recognisable by their thin bark and white blaze, exposing peculiar anastomosing lines in the wood suggestive of annual rings. Common to all species are also the asparagus-like pneumatophores which delineate the spreading and shallow root system,* the yellow somewhat fragrant flowers, and the heart-shaped leathery-skinned fruits; whilst the leaves are characterised by glistening upper surfaces and paler undersides. In the younger stages Avicennia might be confused with Sonneratia, but the leaves of the latter are unmistakable on account of their dullness, the absence of a paler underside, and in the case of *S. alba*, by the purplish colour of the petioles and leaf bases.

Api-api is nearly everywhere regarded with disfavour. In Siam it is described as perfectly useless, growing very fast, and difficult to eradicate, and it is said to suppress and crowd out other valuable species. "Efforts have been made to exterminate it, but this is difficult to do, as even when the tree is cut down it sends up masses of strong stool shoots (compare page 178) and when

* These pneumatophores perform no reproductive function either in this or any other mangrove species.



26. LUDAT (*Avicennia officinalis* Linn.); leaves, flower, and fruit.



27. LUDAT (*Avicennia officinalis* Linn.) ; stem.



(2 m. squares)

28. API-API PUTEH (*Avicennia intermedia* Griff.); leaves and flowers.

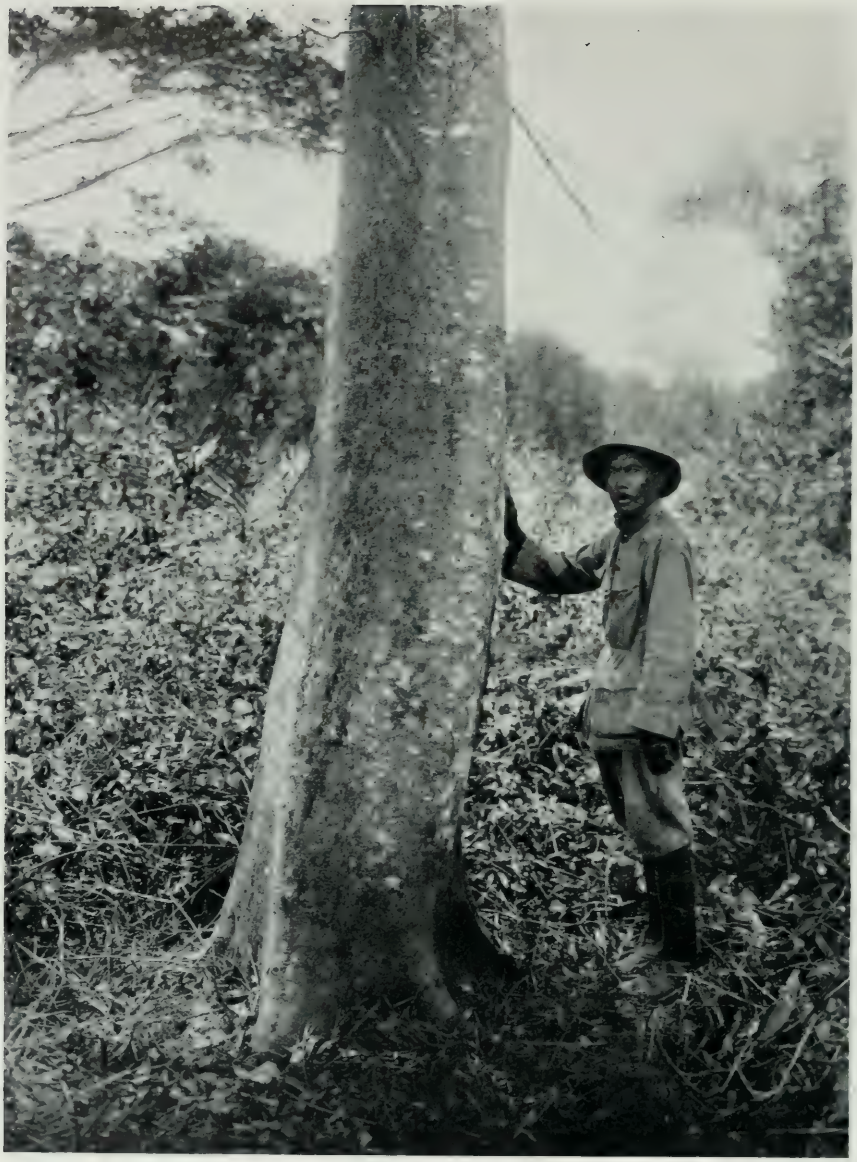


29. API-API PUTEH (*Avicennia intermedia* Griff.); stems.





30. API-API HITAM (*Avicennia alba* Bl.); leaves, flower, and fruit.



31. API-API HITAM (*Avicennia alba* Bl.); stem.



32. API-API (*Avicennia lanata* Ridl.); leaves, buds, and fruit.



33. API-API (*Avicennia lanata* Ridl.); an exceptionally large stem. The climber is an epiphytic Ficus not usually associated with mangrove forests.

girdled often sends down aerial roots from above the girdling point." (40). Foxworthy (13) calls it "the pest of the mangrove swamp" on account of its aggressiveness and comparative worthlessness, and its habit of coming up in abundance where the forest has been cut over.

It is suggested that the genus hardly deserves these harsh names, and that the authors may have lost sight of its usefulness as a pioneer. As far as the local mangrove forests are concerned Avicennia is far from aggressive, and nowhere does it displace the superior species when once the latter have definitely established themselves. An increase in the proportion of *api-api* is almost invariably the result of premature cutting of young swamp, disturbing the natural development of the forest, and thereby forcing this much maligned species to start all over again in its work of consolidating the position. Man, by his interference, is the aggressor. Avicennia is actually the nurse and protector of the superior species.

The four species are compared overleaf.

Avicennia officinalis. *Api-api puteh, Ludat.*	**Avicennia intermedia.** *Api-api puteh, A. mêrah.*
Names:	
(*Specific*)—Presumably from the use of the fruits in native medicine.	From the many characters that are intermediate between the preceding and the following species.
(*Vernacular*)—As for *A. intermedia.* The name *ludat* is not universal, but its use is worth encouraging to prevent confusion. It has no independent meaning.	*Puteh*—from the generally lighter colour as compared with *A. alba. Mêrah*—from the red bark. The latter name is the more apt and might be adopted to save confusion.
Occurrence.	
Sporadic on the banks of streams or inland, particularly on clay soils. Rarely, if ever, gregarious, but occasionally forms a fair proportion of the crop; associated with *Sonneratia acida* and *Nipa fruticans.*	Gregarious on the sea-face in exposed situations in inundation classes 2 and 3, in stiff clay. Rarely found far from the sea, even as a survivor. Commonly associated with *Bruguiera caryophylloides,* which gradually replaces it. Common on the west coast; replaced by *A. lanata* on the east coast.
Size.	
A medium sized tree up to 60′ high.	The smallest of the four species; rarely more than 40′ x 3′, but 70′ x 6′ has been recorded from Penang.
Stem.	
Bole short or of poor shape. Has a tendency to develop ærial roots.	Often bifurcated, generally contorted, never worth considering for timber.
Crown.	
Bushy, dense, clothing the stem.	Light, irregular.

	Avicennia alba. *Api-api hitam.*	**Avicennia lanata.** *Api-api puteh, A. berbulu.*
Names:		
	(*Specific*)—From the white undersides of the leaves.	From the wooly tomentum covering the twigs, undersides of leaves, and inflorescence.
	(*Vernacular*)—From the dark green upper surfaces of the leaves.	As for *A. intermedia*. *Berbulu* means "woolly" and is a description rather than a name—but is worth encouraging.
Occurrence.		
	Gregarious on newly-formed well-drained mud banks, often on the sea-face in inundation class 2, but usually within the influence of a river. Sporadic as a survivor on dry river-banks or inland. Associated with *Sonneratia Griffithii* and *Rhizophora mucronata* and generally indicative of rich soil.	Gregarious on the east coast where it replaces *A. intermedia* in soils which are on the whole, sandier than on the west coast. Sporadic in Singapore. Not found on the west coast.
Size.		
	Occasionally forms quite a large tree (see fig. 31) but not usually more than 70′ x 4′ 6″.	The largest of the species. The tree illustrated in fig. 33 girthed 10′ 6″ and was over 100 feet high, but this is unusual. Average about 70—80 feet.
Stem.		
	Short, cylindrical, not buttressed.	Cylindrical, not buttressed, often with a clear bole.
Crown.		
	Spreading, irregular; twigs pendulous.	Similar to *A. officinalis*.

Avicennia officinalis—(*Contd*).

Bark.

Slightly fissured, grey, lenticellate, closely resembling *A. alba*. Blaze dirty green.

Leaves.

Elliptical 4″ x 2″ margins slightly reflexed; upper surface bright green, lower surface greyish-brown, often in irregular patches.

Inflorescence.

Capitate; peduncles more or less terete, pale green, lenticellate, with fine tomentum; flowers ochre or lemon yellow, ½″ in diameter, very much larger than those of the other species.

Fruit.

Russet-brown, velvety, suggestive of the unopened fruit of an almond, acute but not acuminate 1½″ x 1″ or more.

A. intermedia—(*Contd*).

Thin, reddish brown, mottled green, with papery flakes suggestive of a guava. Blaze bright green.

Elliptical, often sub-acute 3½″ x 1½″ inclined to be asymmetrical, often slightly contorted; light green above, white or greyish beneath.

More or less capitate; peduncles quadrangular, pale green, with sparse tomentum; flowers orange yellow, ¼″ in diameter or less.

Like *A. alba* in colour and *A. officinalis* in shape, but only about ½″ long, with mucronate point. Sometimes as wide as it is long.

Avicennia alba—(*Contd*).	**Avicennia lanata**—(*Contd*).
Bark. Thin, smooth, grey, minutely lenticellate, often covered with sooty rust fungus on branches and upper portion of stem. Blaze bright green.	Similar to *A. officinalis* but rather darker.
Leaves. Acute or acuminate up to 6″ x 2½″, usually smaller; dark green above, silvery grey beneath.	Elliptical, smaller than *A. officinalis*, about 3½″ x 1½″, margin not reflexed; upper surface dark green, lower surface covered with dense pale, fawn-coloured tomentum.
Inflorescence. Spicate; peduncles more or less terete, covered with dense tawny tomentum; flowers orange yellow, 3/16″ in diameter.	Capitate; similar to that of *A. intermedia*, but covered with dense tomentum; flowers, ¼″ in diameter.
Fruit. Green with greyish tomentum, acuminate, ½″ long, in shape resembling a gorged leech.	Larger and proportionately broader than *A. intermedia*, and covered with dense woolly yellow tomentum.

(*iv*) MELIACEAE.

The Genus Carapa.

With the exception of Afzelia (*ipil*) the Carapas are the only trees of the mangrove swamps that have compound leaves. The genus is related, though somewhat distantly, to mahogany, to the timber of which the wood of these trees bears a good deal of resemblance. Although the two species that represent the genus are readily distinguishable in the field, their botanical differences are not so obvious, and there exists considerable confusion in botanical descriptions.

These are discussed in detail in Chapter III. The following are the more obvious characteristics:—

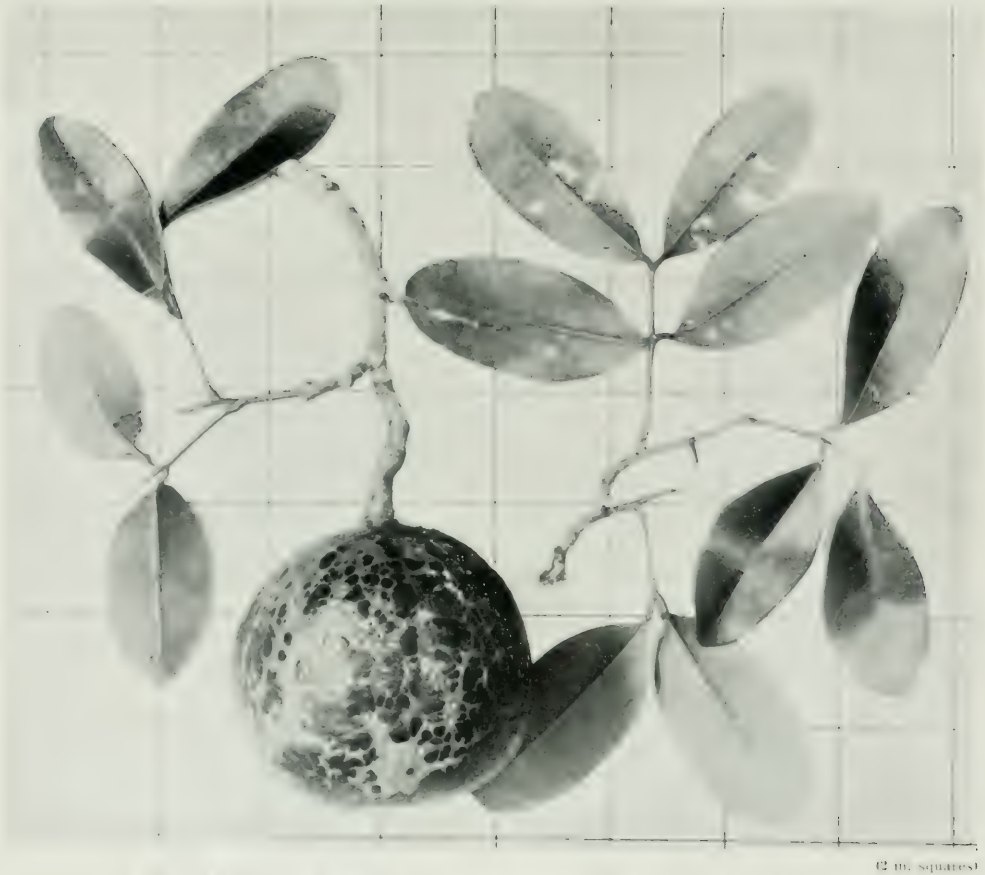
	Carapa obovata. *Nyireh bunga, N. hudang.*	**Carapa moluccensis.** *Nyireh batu.*
Names:	(*Specific*)—From the shape of the leaves which are, however, more elliptical than obovate.	From its distribution through out the Moluccas.
	(*Vernacular*)—*Nyireh* has no definite meaning. *Bunga* means "flower" or "design" and probably refers to the mottled bark, whilst *hudang* (prawn) presumably refers its red colour.	*Batu* (stone) is commonly used with reference to trees, and generally implies that the timber is harder than that of some similar species.
Occurrence.	Sporadic in Rhizophora forest in inundation classes 4 and 5, or even in 3 if the soil is shallow or sandy, under which conditions it may even be gregarious. Replaces superior species in overworked areas.	Sporadic in the dryer areas in inundation classes 4 and 5, further inland and much less common than *C. obovata*, though it largely replaces that species on the west coast further north.
Size.	Up to 60′ x 6′.	Up to 80′ or even 100′ x 7′.
Stem.	Crooked and branched with short bole; older trees usually obviously hollow; produces coppice shoots.	Cylindrical, buttressed, with good straight bole when conditions are favourable; coppice shoots not observed.



34. NYIREH BATU (*Carapa moluccensis* Lam.); leaves and fruit.



35. NYIREH BATU (*Carapa moluccensis* Lam.): stem and pneumatophores.



36. NYIREH BUNGA (*Carapa obovata* Bl.) ; leaves and fruit.



37. NYIREH BUNGA (*Carapa obovata* Bl.); stem and projecting roots.

C. obovata.—(*Contd*).	**C. moluccensis.**—(*Contd*).
Bark.	
Thin, smooth, pale brownish red; flaking off in papery flakes exposing green inner bark.	Thick, dark brown; deeply longitudinally fissured.
Leaflets.	
Leathery; symmetrical.	Less leathery; often asymmetrical.
Fruit.	
Globular, the size of a child's head, turning reddish brown when ripe.	Obscurely four lobed, surface rather irregular, the size of an average orange, turning reddish brown when ripe.
Pneumatophores.	
Surface roots vertically flattened and forming a spreading network on the surface of the soil, suggestive of a mass of snakes.	In addition to being vertically flattened the roots are prolonged at irregular intervals into finger-like projections which may even extend up the buttresses.

(*v*) MALVACEAE.

The littoral members of this family are shrubs or small to medium sized trees and can be readily recognised by their large, alternate, radially-veined, broadly heart-shaped, acuminate leaves, and large yellow crimson-centred flowers. Two genera occur (Hibiscus and Thespesia), each represented by a single species, viz:

Hibiscus tiliaceus.	**Thespesia populnea.**
Baru, Waru, Bebaru.	
Names:	
(*Specific*)—From the resemblance of the leaves to those of the European lime or linden (Tilia).	From the resemblance of the leaves to those of a black poplar (Populus).
(*Vernacular*)—No independent meaning.	
Occurrence.	
On the banks of tidal rivers, some little distance from the sea.	On the coast on sandy beaches.
Size.	
A straggling shrub, or a small tree up to 30′ x 3′.	Rather larger than the preceding; up to 35′ x 4′.

Hibiscus tiliaceus.—(*Contd*).	**Thespesia populnea.**—(*Contd*).
Leaves.	
Grey beneath; margins entire or minutely toothed; as broad as or broader than long.	Not grey beneath; margins entire or waved; rather longer than wide.
Flowers.	
Turn red on withering; calyx sharply lobed.	Turn purplish pink on withering; calyx not lobed.
Fruit.	
Oblong, pointed; densely hairy.	Depressed globose; minutely scaly or glabrous.

(*vi*) STERCULIACEAE.

The Genus Heritiera.

Only one species occurs in or near the mangrove swamps, viz: *H. littoralis*. *H. minor* (Bengali-*sundri*) occupies an important place in the littoral forests of India and Burma and by virtue of its abundance and the excellent quality of its timber, plays a leading part in the working plans for such areas. *H. littoralis* makes no such claim to attention in Malaya. Nowhere abundant, it is usually represented by an occasional clump of badly shaped shrubby trees, the timber of which, though durable enough, is not obtainable in sufficiently large pieces to fit it for anything but occasional domestic uses (*e.g.*, rice mortars) where it happens to be convenient.

Heritiera littoralis. *Dungun, Pelir kambing, Bayor laut.*

Names. The specific name refers to its habitat near the sea shore. The first Malay name has no definite meaning; the second is an indecent but apt description of the shape of the fruit; the name *bayor* is common to many members of the family Sterculiaceae, though it has no definite meaning; *laut* means "sea" and refers to the habitat.

Occurrence. Sporadic in dry mangrove in inundation class 5 where the soil is sandy; at its best in the *nipah* belt.

Size. 35′ x 2′ 6″, occasionally larger.

Stem. Irregularly shaped, much branched.

Bark. Grey, thick, fissured, with reddish lenticels.

Twigs. Grey, silvery scaled with black spots.

Leaves. Irregularly oblong or elliptic, about 6″ x 3″, usually rounded at the base; dark green above; silvery, minutely spotted with brown beneath.

Flowers. Inconspicuous; petals grey outside, dark claret-coloured inside.

Fruit. Hard, woody, about 1½″ long, deeply keeled on one side.

Pneumatophores. None seen.

(*vii*) TILIACEAE.

The Genus Brownlowia.

This genus is represented by two species, neither of which occurs in sufficient abundance to warrant more than passing mention. Both grow on the outskirts of the mangrove. Their chief distinctive feature lies in the brownish-grey, scaly undersides of the leaves, in which respect they resemble those of Heritiera, though the latter are more silvery. Neither has any known use.

Brownlowia lanceolata. *Durian laut.*

Names. Both the specific and Malay names refer to the appearance of the leaf, the former describing its shape, and the latter its resemblance to that of the *durian.*

Occurrence. On the banks of streams some distance upstream, sometimes forming dense masses in inundation class 4.

Size. A low shrub.

Leaves. Dark green above, scaly brownish-grey beneath; in size, colour, and shape, resembling those of the *durian.*

Flowers and Fruit. Inconspicuous.

Brownlowia Kiedelii. Native name uncertain, but has been recorded as *walan*, which has no independent meaning.

Occurrence. Sporadically on the edge of the swamp, particularly where the soil is sandy, in similar positions to Heritiera (*dungun*) for which it is sometimes mistaken, but from which it can be distinguished by its cordate leaves (q.v.). Has not been recorded from the west coast.

Size. A small, shrubby tree.

Leaves. Much larger than those of the preceding species, ovate, suggestive of Heritiera but distinguishable from that species by the brownish colour of their undersides, by their cordate bases, and by their longer and slenderer petioles.

Flowers and Fruit. Inconspicuous.

(*viii*) COMBRETACEAE.

The Genus Lumnitzera.

Two species occur in the swamps. The leaves of both are fleshy, narrowly obovate or spathulate, rarely more than 3″ long, and about 3 times as long as broad. They differ from those of other mangrove trees (with the exception of *Sonneratia acida—berembang*) in being quite sessile. The fruit is a glossy fibrous drupe about ½″ long, tapering towards the apex and crowned with the persistent calyx. In their shrubby state, and in the absence of flowers or fruit, both species might at first sight be mistaken for

Scyphiphora or Aegiceras, but Scyphiphora has opposite, distinctly petiolate, round leaves, the two terminal ones of which are sticky and closely adpressed, whilst in Aegiceras the leaves are alternate, shortly petioled, are usually less than twice as long as broad, and have entire and slightly reflexed margins. The two species compare with each other as follows:—

Lumnitzera coccinea. *Teruntum.*

Names. Specific—from the scarlet colour of the flowers. The Malay name has no special meaning.

Occurrence. Very local. Rare or entirely absent over large areas in Perak. Often gregarious as a shrub in sandy soils in inundation class 4 near the sea; sporadic as a large tree further inland. Some quite exceptional trees are growing near the boundary of the Kapar Reserve in Selangor in inundation class 5.

Size. Usually shrubby, but in favourable localities is capable of growing into really large trees up to 120′ high and 10′ in girth.

Stem. Good straight cylindrical bole with no buttresses.

Bark. Soft, brown or grey, rough, fissured, with large, soft, pale, pinkish, lenticels.

Inflorescence. Umbellate, conspicuous, flowers scarlet.

Fruit. A small drupe about ½″ long; green, tinged with red; in umbellate clusters.

Pneumatophores. Small and inconspicuous vertically projecting loops in the surface roots; noticeably lenticellate.

Lumnitzera racemosa. *Teruntum, Sesup.*

This closely resembles the foregoing species in general appearance and habitat. It is, however, very much smaller, rarely if ever growing more than 20′ high, and ordinarily forming little more than a shrub. It can be distinguished from *L. coccinea* by its conspicuous lax racemes of white flowers, and by the corresponding arrangement of the fruit.

(*ix*) LEGUMINOSAE.

The Genus Derris.

Represented by a single species that takes the form of either straggling shrub or climber according to circumstances.

Derris uliginosa. *Setui, Ketui.*

Names. Specific, from its habitat in swamps. The Malay names have no independent meaning.

Occurrence. On the banks of tidal streams and in open places near the sea that have been cleared or reclaimed.

Size. Usually forms an inconspicuous shrub, though under conditions that are no longer describable as true mangrove swamp it can develop into quite a respectable climber.



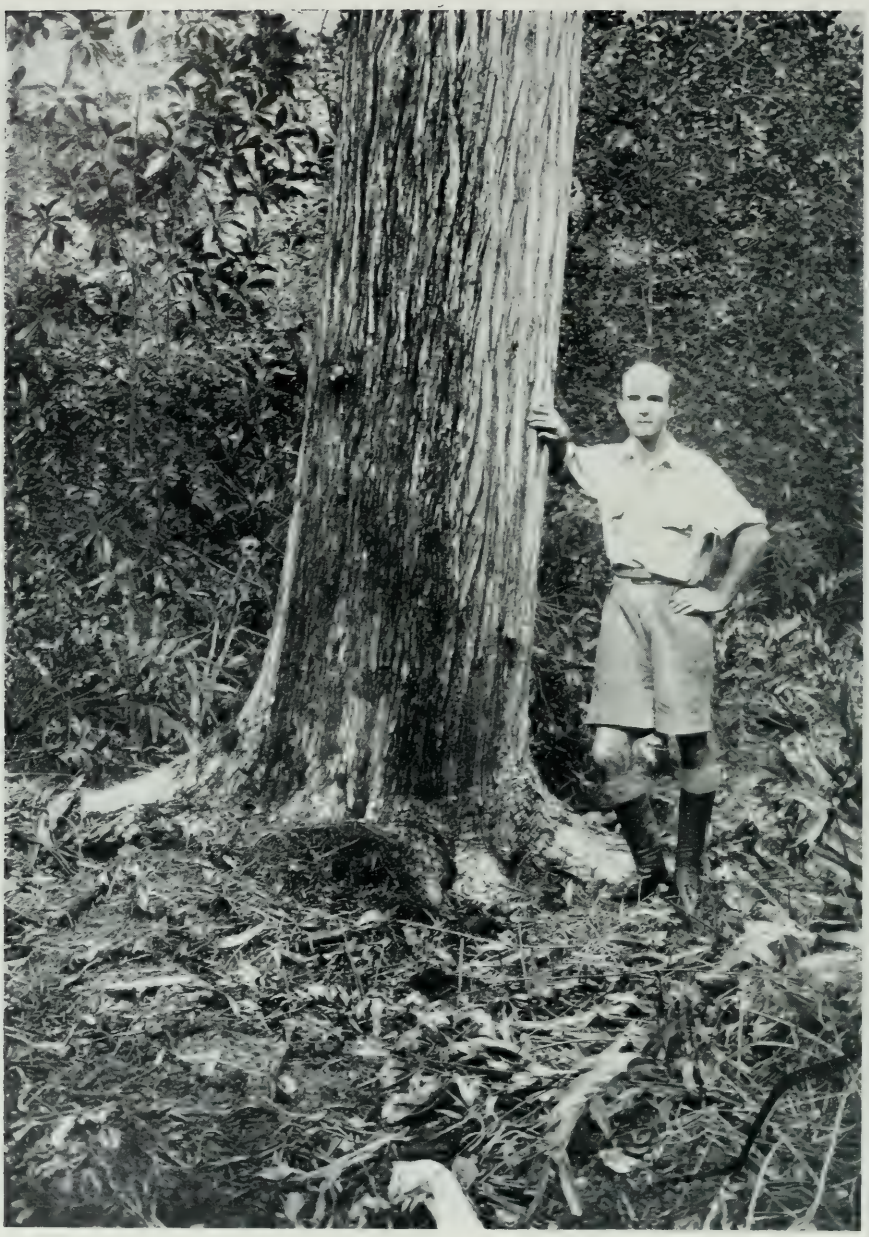
(2 in. squares)

38. TERUNTUM (*Lumnitzera racemosa* Willd.); leaves, flowers, and fruit.



(2 in. squares)

39. TERUNTUM (*Lumnitzera coccinea* Wight.); leaves, flowers, and fruit.



40. TERUNTUM (*Lumnitzera coccinea* Wight.); stem.



41. IPIL (*Intsia retusa* (Colebr.) O.K.); stem.



42. BUTA-BUTA (*Excoecaria Agallocha* Linn.); stem.

Derris uliginosa.—(*Contd*).

Leaves. Compound; leaflets acuminate, about 3″ long, in fives or threes; green, glabrous above and below.

Inflorescence. A many flowered erect raceme; flowers typically leguminous, white or pinkish.

Fruit. A flat, single seeded, almost circular green pod, about an inch in diameter.

The Genus Intsia.

The mangrove swamp representative is not unlike the inland type *Intsia Bakeri* (*merbau*), but is considerably smaller and not so highly valued as a timber tree.

Intsia (Afzelia) retusa. *Ipil, Merbau ipil.*

Name. Scientific—from the shape of the leaflets; Malay—no independent meaning.

Occurrence. In dry mangrove in inundation class 5 at some distance from the sea; usually associated with *Bruguiera gymnorhiza*, Carapa and Acrostichum.

Size. Up to 80′ high and 6′ in girth above buttresses. Crown small, flat-topped.

Stem. Cylindrical; heavily buttressed; usually with clear bole for the greater part of its length.

Bark. Reddish brown, smooth, thin, flaking off in circular patches.

Leaves. Compound; leaflets 4, rounded at base and apex, often almost circular; petiolules twisted.

Inflorescence. Rarely seen; flowers pinkish, turning purple.

Fruit. A flat pod, 5 to 6 inches long, with hard flat seeds suggestive of broad-beans.

Pneumatophores. Apparently absent. At most an upward-curving tendency of the surface roots.

(*x*) EUPHORBIACEAE.

The Genus Excoecaria.

Three species are found in the Malay Peninsula, but only one grows in the mangrove forests. Excoecaria is peculiar in being almost or quite leafless during the flowering season when, owing largely to its catkin-like male flowers, it resembles a poplar or willow. Like Cerbera it has a milky latex but there is no other similarity between the two trees, though they are frequently confused.

Excoecaria Agallocha. *Buta-buta, Bebuta.*

Names. Specific—from the occasional formation of fragrant resinified heart-wood, similar to that known as Agallochum, Aloes, or Eagle wood, and used for incense. The Malay name refers to the poisonous latex, which causes temporary blindness if it comes in contact with the eyes, and will even blister delicate skins on other parts of the body.*

Occurrence. Distribution local; sporadic in the drier areas, particularly on heavy soils. Commonly associated with *Bruguiera caryophylloides* on the landward side in inundation class 5.

Size. Usually multi-stemmed or shrubby, but can grow into a large tree up to 80′ in height with a girth of 6′ or more.

Stem. Cylindrical, not buttressed; apt to fork.

Bark. Grey, with red-brown lenticels joining one another to form irregular vertical or diagonal stripes.

Leaves. Alternate, up to 4½″ x 2½″ but usually smaller; green, glabrous above and below, margin slightly wavy; petiole about 1″ long, slender, grooved above.

Inflorescence. Male flowers in slender green catkins; female flowers stalked, in short racemes.

Fruit. A smooth 3-lobed capsule, like a small Para rubber fruit.

Pneumatophores. Lenticellate, snake-like curvatures of the ordinary roots; not always obvious.

(*xi*) RUBIACEAE.

The Genus Scyphiphora.

One species only is found in the mangrove. It grows into a tall, erect, bushy shrub which might, as mentioned on page 46 be confused with a small Ceriops. Its resemblance to Lumnitzera and, by inference, to Aegiceras, has already been referred to on page 78 in describing the former genus. The most distinctive and ever present characteristics of Scyphiphora are the dry gumminess of the young petioles, and the closely opposed upper surfaces of the two sticky young terminal leaves.

Scyphiphora hydrophyllacea. *Chingam, Chengam.*

Name. The generic name means "cup-bearing," and probably refers to the remains of the calyx tube which surmount the fruit. The specific name implies a resemblance to the genus Hydrophyllum but is more easily remembered as suggestive of the habitat. The Malay names have no particular significance.

Occurrence. Sometimes semi-gregarious in patches in old clearings in wet mangrove, and sporadic on the banks of tidal streams. Rare or absent over the greater portion of the mangrove swamps in Perak. Common in most other places.

* According to Heyne (23) the best treatment is to bathe the affected eye frequently with coconut oil.



(2 in. squares)

43. CHINGAM (*Scyphiphora hydrophyllacea* Gaertn.); leaves, flowers, and fruit.



(2 in. squares)

44. KACHANG-KACHANG (*Aegiceras majus* Gaertn.); leaves, flowers, and fruit.

Scyphiphora hydrophyllacea.—(*Contd*).

Habit. Up to 12′ in height; shrubby.

Twigs. Stout, stiff, at right angles to the branches, green or reddish, gummy when young.

Leaves. Obovate, opposite, shining, entire; terminal leaves sticky, their faces closely adpressed.

Inflorescence. Flowers white or pinkish in axillary clusters.

Fruit. In dense axillary clusters, green, about one third of an inch long, almost cylindrical, deeply longitudinally ribbed, surmounted by calyx tube.

(*xii*) COMPOSITAE.

The Genus Pluchea.

The single mangrove species of this genus deserves only passing mention. It is an inhabitant of alienated agricultural land bordering the swamps, rather than of the swamps themselves, but it occasionally finds its way into clearings in the forest.

Pluchea indica. *Beluntas.*

Easily recognisable by its typical compositous inflorescence of small mauve or pinkish flowers, forming dense heads. It occurs gregariously in clearings and on the high banks of streams, often in association with Acanthus and Acrostichum in inundation class 5. In habit it is an erect and much branched shrubby herb that may reach a height of 6 or 8 feet, but is generally much smaller. The leaves are sessile, or nearly so, 1½″ to 3″ long, with a toothed margin. The flowers have already been described; the fruits are very small, with a dirty white pappus. It has no local use and can be regarded as a harmless weed.

(*xiii*) MYRSINACEAE.

The Genus Aegiceras.

Another genus represented by a single, unimportant, shrubby species, viz:

Aegiceras majus. *Kachang-kachang, Kuku lang laut.* Often erroneously called *Teruntum.*

Names. "Aegiceras" from the resemblance of the fruit to a ram's horn. The Malay names suggest a likeness to pea-pods or to eagle's claws.

Occurrence. On the banks of tidal streams subject to inundation; generally common not far from the sea, but rare in Perak.

Habit. An erect shrub up to 12′ in height.

Leaves. Scattered, alternate, obovate, almost sessile, narrowed to the base, with reflexed margin, the apex often notched.

Inflorescence. Conspicuous, umbellate; flowers white, fragrant.

Fruit. In umbellate clusters, green or pinkish, curved, like miniature sharp pointed bananas, about 1½″ to 2″ long.

(*xiv*) APOCYNACEAE.

The Genus Cerbera.

The Cerberas are distinguishable from other mangrove species by their milky juice, a characteristic that is shared only by Excoecaria. Two species are described by Ridley (41), who says that they are frequently confused. The differences lie in somewhat inconspicuous botanical details which need not be considered here. For the purposes of this *Record* the two species will be described together. Neither of them is of any economic importance.

Cerbera lactaria and **C. Odollam.** *Pongpong,* (*Buta-buta*).

Names. The generic name implies that the genus is harmful, like Cerberus. The specific name of the first species has reference to the milky latex which is, however, common to both. Malays frequently misname both trees *buta-buta*, from the mistaken belief that the latex, like that of Excoecaria (the true *buta-buta*) causes blindness. The real Malay name, *pongpong*, appears to have no independent meaning.

Occurrence. C. lactaria prefers the banks of streams, well up to the extreme tidal limit. *C. Odollam* is found in sandy places along the sea shore.

Size. Small bushy trees up to 30′ high.

Bark. Grey, pustular.

Stem. More definite in *C. Odollam* than *C. lactaria*; conically thickened at base.

Leaves. Up to a foot or more in length, tapering into a stout petiole. *C. lactaria* has shorter and proportionately broader leaves than the other species.

Twigs. Stout, marked with leaf scars.

Inflorescence. Terminal; flowers white and showy, rather suggestive of tobacco flowers. *C. Odollam* has a yellow throat, whilst that of *C. lactaria* is red.

Fruit. Globular, green, fibrous, 2 to 4 inches in diameter, turning red and resembling an apple when ripe. Is carried long distances by ocean currents, and its fibrous skeleton is a common object amongst the jetsam on sea beaches.



(2 in. squares)

45. JERUJU (*Acanthus ilicifolius* Linn.); leaves, flowers, and fruit.



46. JERUJU (*Acanthus ilicifolius* Linn.). The palm on the left is NIPAH (*Nipa fruticans* Wurmb.).

(*xv*) ACANTHACEAE.

The Genus Acanthus.

The genus Acanthus comprises one climbing and two unmistakable erect hollow-stemmed thistle or holly-like shrubs from 4 to 8 feet high. The latter, which alone are dealt with here, and which closely resemble one another, often possess miniature stilt-roots, similar to those of Rhizophora, have conspicuous flowers, and are commonly found (particularly in stiff soils) on the banks of tidal streams some distance from the sea, or in clearings in the mangrove forest, often replacing Acrostichum in inundation class 5. In the 1922 working plan for the Coringa (Madras)* forest reserve it is recommended that Acanthus should be preserved, as it is instrumental in holding up the floating Avicennia seeds and because it serves as a nurse to the various species of that genus that go to form the bulk of the crop.

Acanthus ebracteatus. *Jeruju* (*hitam*).

Name. "Ebracteatus"—from the early falling of the conspicuous floral bracts. The Malay names have no particular significance; the adjective "*hitam*" (black) possibly applies to the dark green of the leaves, but it is not recognised in many places.

Inflorescence. Flowers white; bracts fall off at an early stage.

Fruit. Capsular; under 1″ long; green; containing several flat seeds about ¼″ in diameter, like miniature broad beans.

Acanthus ilicifolius. *Jeruju* (*puteh*).

Name. The specific name refers to the holly-like leaves, and would apply equally well to either species. The Malay adjective "*puteh*" (white) is misleading, the flowers of this species being definitely blue. It appears to refer to the lighter colour of the leaves, but the difference between the species is not everywhere recognised by Malays.

Inflorescence. Flowers blue, larger than those of *A. ebracteatus;* bracts persistent.

Fruit. Capsular, over 1″ long, green; seeds as in preceding species.

(*xvi*) PALMAE.

The two non-climbing palms of the mangrove belt have very large pinnate leaves with narrow leaflets. The climbing kinds, or rattans, are represented by a single species which begins on the landward edge of the true mangrove area and is not, properly speaking, a true inhabitant of the salt water swamps.

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* See page 178.

Oncosperma filamentosa. *Nibong.*

Name. The scientific names are obscure. The Malay name has no definite meaning.

Occurrence. On the landward side of the swamps, or in the interior of islands, above the influence of salt water. Grows equally well inland, and even on hills far from the sea. Is likely to be killed by salt water inundation.

Habit. A tall, many-stemmed palm, 50′ to 100′ high and 2′ in girth.

Stem. Grey, or almost black, armed with strong black spines.

Leaves. Drooping, 10′ to 12′ long.

Fruit. Small, globular; at first red, turning black when old.

Regeneration of this palm is said by Malays in Lower Perak to be entirely by root suckers. Examination of areas in which it is plentiful has failed to reveal seedlings and none of the seed that has been sown has ever germinated. Local opinion is, however, by no means unanimous on this point, and further experiments are proceeding.

Nipa fruticans. *Nipah.*

Names. The generic name is taken from the Malay and has no particular meaning. The specific name refers to the shrubby habit.

Occurrence. Often gregarious, though never very extensively so in this country. At its best along the banks of tidal rivers where the water is almost if not quite fresh at low tide. Dennett (9) records considerable retardation of growth in Nipah plantations following flooding by salt water in 1926.

Habit. A shrubby palm with a prostrate, creeping stem and large erect leaves.

Stem. Ringed, unarmed, very short.

Leaves. Erect, 15′ to 20′ long, unarmed, smooth and shining.

Fruit. A drooping globose head a foot or more in diameter, at first green, turning brown when ripe.

Daemonorops leptopus. *Rotan bakau.*

Names. Generic—from its affinity with the species that yield Dragon's Blood (a red resinous substance used as a varnish stain); *specific*—from the slender stem, a characteristic that is common to most rattans; *Malay*—from its habitat in or near the mangrove swamp (*bakau*).

This species, being the only climbing palm that occurs anywhere near the mangrove, requires but scant mention. It does not grow in the mangrove proper, and it is commonest along river

banks above the nipah zone. It is of no commercial importance, but is used for tying where nothing better is available. It is easily recognisable by its habit and, at closer quarters, by the thorny flagella into which its leaves are prolonged.

(*xvii*) CONIFERAE.

The order *Coniferae* is but sparingly represented in Malaya, and not at all in the mangrove swamps proper.* On the outskirts, however, where the soil is sandy, it is not unusual to find (particularly on the east coast) occasional specimens of:

Podocarpus polystachyus, known to the Malays for some obscure reason as *jati laut*. "*Jati*" is the name for teak, and has come by circuitous paths to be used for imported coniferous woods such as deal. This species does not usually grow into anything larger than a small bushy tree, recognisable by its somewhat tufted, dark green, leathery, pointed, typically coniferous leaves, which smell strongly of turpentine when crushed. The tree has no particular value and is nowhere abundant.

(*xviii*) CYCADACEAE.

The Genus Cycas.

The species that is found on the outskirts of the mangrove swamps is equally happy far inland on high hills. In the littoral forests it is an inhabitant of rocky foreshores rather than mangrove, occupying in the latter a similar position to Podocarpus (q. v.).

Cycas Rumphii. *Paku laut, Paku gajah, Paku haji.*

In spite of its Malay appellation (*paku*=fern) this is, of course, not a fern, though its symmetrical artificial-looking radiating fronds with their narrow, dark green, leathery, shining, leaflets rather suggest kinship with that family. Cycas is far commoner on the east coast than on the west, though nowhere can it be said to be abundant. The male cones are very conspicuous, sometimes reaching a length of a foot or more. The seeds are borne on the edges of a flattened organ known as a carpophyll, and are almost globular, an inch or more in diameter, with a hard shell. They float and are carried long distances by ocean currents.

The plant has no local value beyond that of an ornamental shrub in gardens.

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* An interesting account of an unusual stand of *Agathis alba* immediately adjoining a mangrove swamp in Sarawak is given by Mr. J. P. Mead in the *Empire Forestry Journal* Vol. 5 page 178. Similar stands are described by Mr. T. Corson on page 291 of Volume 6 of the same publication. On the eve of going to press, specimens of this tree have been received from the Dindings, where it is reported to be growing sporadically on the landward side of the mangrove.

(*xix*) FILICES.

Only one terrestrial fern is at all common in the mangrove, but it is common enough to be a serious nuisance.

Acrostichum aureum, *Piai lasa, Piai raya, Larat*, is a fern with thick rhizomes and large pinnate fronds. On fairly dry soils, where there is sufficient light, it often forms an impenetrable undergrowth up to 12 feet high, but in wetter or darker areas it is thin and stunted. The Malay word "*raya*" means "large," and is applied to the luxuriant form that is found in the dryer places; "*lasa*" means "numbed" and may possibly have reference to the stunted growth of the fern under less favourable conditions. "*Larat*" means "spreading, like fire or disease," doubtless from the manner in which the fern takes charge in denuded areas.

Acrostichum, if not controlled, can be one of the biggest pests in the mangrove. It is described in some detail in Chapter IV (d), where illustrations of the two forms will also be found. (P. 152).

Mention should also be made of the following plants which, though not, strictly speaking, inhabiting the mangrove swamps, occur on its outskirts sufficiently frequently to attract attention:

Ficus sp. (*jejawi*); epiphytic figs common in dry mangrove, where they play the part of pioneers in the transition to inland forest. *Morinda spp.* (*mengkudu*); shrubs with dark green leaves and soft green fruits suggestive of many-eyed potatoes. *Allophylus glaber* (*mata pelandok* or *chinchang*); shrubs with trifoliate leaves and spicate inflorescence. *Ardisia crenata* (also called *mata pelandok* but, more correctly, *mata ayam*); shrubs with dark green toothed leaves and pink flowers. *Sideroxylon ferrugineum* (*barat laut* or *tuak-tuak*); medium sized trees with copper-coloured undersides to the leaves. *Elaeodendron subrotundum* (*mempenai*); shrubs or small trees with round leaves and small brown fruits. *Terminalia Catappa* (*ketapang*); a large spreading tree, common on beaches or behind coastal mangrove. *Barringtonia speciosa* (*putat laut*); a small tree, common on the east coast, with large fibrous fruits that are square in section. *Ruellia tuberosa* (native name unknown); small woody herbs with bright blue trumpet-shaped flowers and explosive pod-like capsules. *Caesalpinia Bonduc* (*gorek* or *kelubu*); leguminous climbers with fine pinnate leaves and grey intensely hard seeds that are said to have anthelmintic properties. *Hernandia peltata* (*buah keras laut*); shrubby trees suggestive of Thespesia (q.v.) but with inconspicuous unisexual flowers and inflated fruits. *Tristellateia australasica*; a climber with handsome yellow flowers, frequently cultivated in gardens. *Flagellaria indica* (*rotan dini*);

not a *rotan*, but suggestive of one, with its leaves produced into tendrils with which it climbs. *Crinum asiaticum* (*tembaga suasa*); a well-known liliaceous plant with white flowers and red stamens. *Paramignya longispina* (*limau lèlang*); a shrub or small tree with long spines that make themselves unpleasantly felt in dry mangrove. *Scsuvium portulacastrum* (*gèlang*); a creeping succulent herb suggestive of the Mesembryanthemums that are common in seaside places in the warmer parts of England, and that has given its name —mutilated into "Geylang"—to a road in Singapore. *Pandanus spp.* (*pandan* or *mengkuang*); armed or unarmed screw-pines, some of which have fruits suggestive of a pineapple.

(*e*) Key to Identification.

The following key, combined with the illustrations, leaf diagrams, and descriptions that follow, should enable anyone to identify the principal species without trouble.

I. TREES.

A. With Stilt-Roots.

(i). **Bark horizontally fissured, almost black.**	Bakau Kurap. *Rhizophora mucronata* 4*
(ii). **Bark greyish, smooth or furrowed.**	Bakau Minyak. *Rhizophora conjugata* 2.a.
(iii). **Bark lenticellate; stilt roots generally absent or inconspicuous.**	Mata Buaya. *Bruguiera eriopetala* 3.b.

B. With Ordinary Buttresses.

(i). **Bark not furrowed.**	
(a). Light brown, lenticellate, buttresses fluted.	Tengar. *Ceriops Candolleana* 8.a.
(b). Grey, lenticellate, buttresses abrupt.	Berus. *Bruguiera caryophylloides* 3.c.
(c). Grey, smooth, normally buttressed.	Lenggadai. *Bruguiera parviflora* 3.d.
(d). Grey or reddish, smooth, pitted.	Ipil. *Intsia retusa* 16.b.
(e). Reddish with papery flakes; roots serpentine.	Nyireh Bunga. *Carapa obovata* 6.c.
(ii). **Bark furrowed:**	
(a). Brown or black, not flaking off.	Tumu. *Bruguiera gymnorhiza* 3.a.
(b). Brown or black, with conspicuous lenticels.	Mata Buaya. *Bruguiera eriopetala* 3.b.
(c). Dark chocolate brown, with large imbricate flakes.	Nyireh Batu. *Carapa moluccenis* 9.c.
(d). Light grey with reddish lenticels.	Dungun. *Heritiera littoralis* 9.a.

* The numbers refer to the corresponding leaf diagrams, on pp. 98—103.

I. Trees.—(*Contd*).

C. BUTTRESSES INCONSPICUOUS OR ABSENT.

(i). **Bark not furrowed:**

(a). Red-brown with papery flakes.	API-API PUTEH. *Avicennia intermedia*	9.b.*
(b). *(c)*. *(d)*. Grey, smooth, minutely lenticellate.	API-API HITAM. *Avicennia alba*	10.a.
	API-API LUDAT. *Avicennia officinalis*	6.a.
	API-API BERBULU. *Avicennia lanata*	8.c. 6.b.
(e). Grey with red-brown lenticels forming diagonal stripes, and copious white sap.	BUTA-BUTA. *Excoecaria Agallocha*	10.c.

(ii). **Bark furrowed:**

(a). Brown or reddish, twigs pendulous.	BEREMBANG. *Sonneratia acida*	2.c.
(b). Brown or reddish, twigs stiff.	PEREPAT. *Sonneratia Griffithii*	8.b.
(c). Brown or reddish, twigs stiff.	GEDABU. *Sonneratia alba*	16.a.
(d). Soft with large pale pinkish lenticels; flowers red.	TERUNTUM. *Lumnitzera coccinea*	12.a.
(e). Soft with large pale pinkish lenticels; flowers white.	TERUNTUM. *Lumnitzera racemosa*	12.b.

D. STEMS CONICALLY THICKENED AT BASE.

(i). **Bark smooth, reddish, lenticellate.**	BERUS-BERUS. *Kandelia Rheedii*	5
(ii). **Bark pustular with milky sap.**	PONGPONG. *Cerbera spp.*	11

* The numbers refer to the corresponding leaf diagrams, on pp. 98—103.

II. SHRUBS.

A. WOODY.

(i). **Leaves opposite; simple.** Young leaves gummy, twigs pink.	CHINGAM. *Scyphiphora hydrophyllacea*	7.*
(ii). **Leaves alternate; simple.**		
(a). Leaves green above and below.	KACHANG-KACHANG. *Aegiceras majus.*	13
(b). Shrubby trees with conspicuous yellow flowers.	BARU. *Hibiscus tiliaceus*	15
	BARU. *Thespesia populnea*	14.a.
(c). Leaves with scaly brown undersides.	WALAN(?) *Brownlowia Riedelii*	14.b.
	DURIAN LAUT. *B. lanceolata*	2.b.10b.
(iii). **Leaves alternate; compound.** Semi-climbers with flat green pods.	SETUI, SALANG. *Derris uliginosa*	10.d.

B. HERBACEOUS.

(i). **Leaves prickly.** *(a).* Flowers white, fruit less than 1".	JERUJU HITAM. *Acanthus ebracteatus*	18.b.
(b). Flowers blue, fruit more than 1".	JERUJU PUTEH. *Acanthus ilicifolius*	18.a.
(ii). **Leaves flaccid:** Flower heads pink.	BELUNTAS. *Pluchea indica.*	17

III. PALMS.

(i). **Erect, with armed stems.**	NIBONG. *Oncosperma filamentosa*	
(ii). **Erect, stemless, unarmed.**	NIPAH. *Nipa fruticans*	
(iii). **Climbing, with hooked flagella.**	ROTAN BAKAU. *Daemonorops leptopus*	

IV. CONIFERS.

Small trees with alternate dark green leathery leaves.	JATI LAUT. *Podocarpus polystachyus*	1

V. CYCADS.

Plants with radiating fronds and leathery dark green leaflets.	PAKU LAUT. *Cycas Rumphii.*	1

VI. FERNS.

Coarse leaved ferns forming dense masses.	PIAI. *Acrostichum aureum.*	

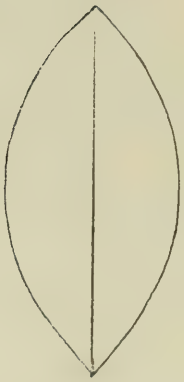
* The numbers refer to the corresponding leaf diagrams, on pp. 98—103.



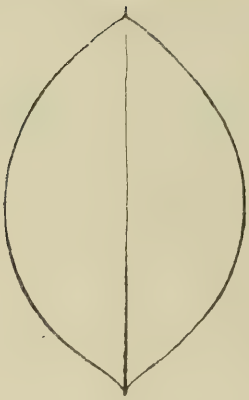
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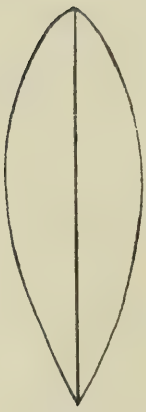
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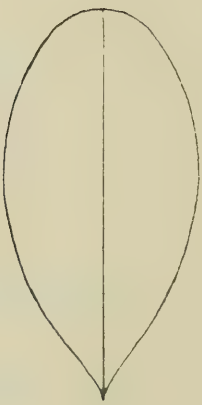
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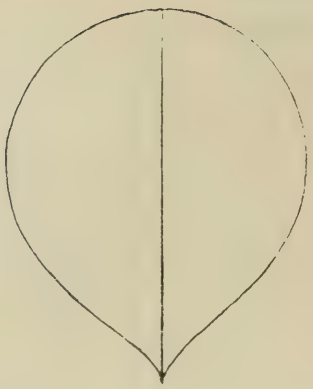


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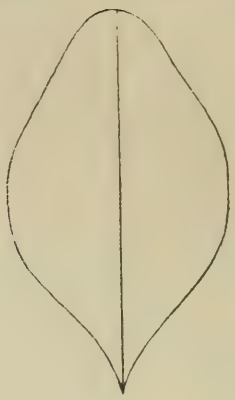
LEAF DESCRIPTIONS.

Note. Leaves are simple and opposite unless otherwise stated. The numbers refer to the diagrams opposite.

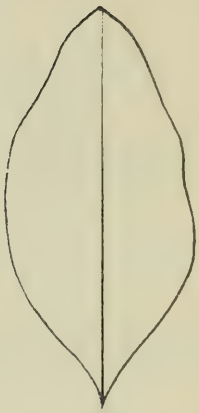
1.a. 3″, alternate. Small coniferous trees with brown fissured bark.	JATI LAUT. *Podocarpus polystachyus.*
b. Compound; leaflets up to a foot or more. Palm-like shrubs with short stems and radiating fronds.	PAKU LAUT. *Cycas Rumphii.*
2.a. 6″, midrib red, black dots on underside, mucronate. Trees with stilt-roots and grey bark.	BAKAU MINYAK. *Rhizophora conjugata.*
b. 5″, midrib green, whole leaf usually yellowish. Normally buttressed trees with smooth grey bark. (See also 3.d.)	LENGGADAI. *Bruguiera parviflora.*
c. 4″, sessile, base of leaf and midrib crimson. Trees with brown fissured bark, pendulous twigs, and edible fruits.	BEREMBANG. *Sonneratia acida.*
d. 4″, alternate, under surface with brownish scales like *durian* leaf. Low shrubs on river banks. (See also 10.b.)	DURIAN LAUT. *Brownlowia lanceolata.*
3.a. 6″, midrib red, no black dots beneath; flowers over 1″ long, scarlet. Trees with rough fissured brown bark.	TUMU. *Bruguiera gymnorhiza.*
b. 5″, midrib pink or green; flowers under 1″ long, yellowish, green, or pinkish. Trees with lenticellate fissured bark.	MATA BUAYA. *Bruguiera eriopetala.*
c. 4″, midrib green; young shoots with salty leguminous taste. Trees with grey smooth lenticellate bark and abrupt buttresses. Compare 3.d.	BERUS. *Bruguiera caryophylloides.*
d. 5″, whole leaf usually yellowish; young shoots with astringent taste. Trees with smooth bark and normal buttresses. Compare (c) above and 2.b.	LENGGADAI. *Bruguiera parviflora.*
4. 7″, tip mucronate, under surface with black dots. Trees with stilt-roots and dark rough bark.	BAKAU KURAP. *Rhizophora mucronata.*
5. 4″, margins reflexed; leaf buds twisted like an auger point. Small trees with conically thickened stems.	BERUS-BERUS. *Kandelia Rheedii.*
6.a. 4″, margins reflexed, under surface patchily or completely grey but not woolly. Bushy trees with grey bark.	LUDAT. *Avicennia officinalis.*
b. 3½″, under surface densely woolly; shape more usually as in 8 (c). Tall trees with grey bark.	API-API BERBULU. *Avicennia lanata.*
c. Compound; leaflets 4″, under surface green with net-like venation. Trees with reddish papery-flaked bark.	NYIREH BUNGA. *Carapa obovata.*



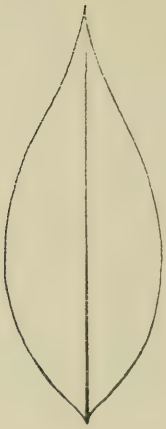
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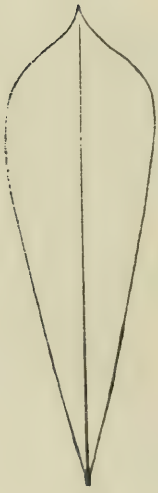
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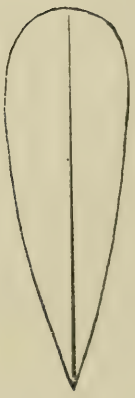
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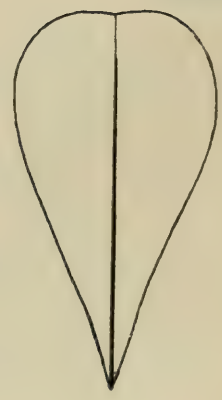


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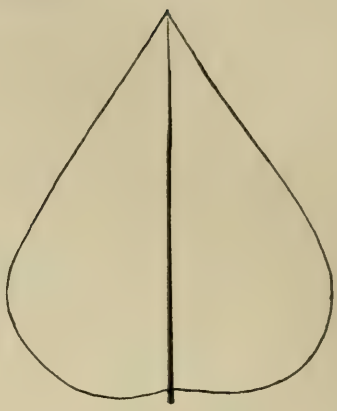


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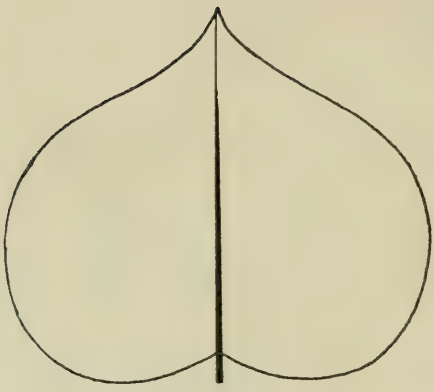
7.	2″, petioles and young shoots gummy; terminal leaves with faces closely adpressed. Bushy shrubs.	CHINGAM. *Scyphiphora hydrophyllacea.*
8.a.	4″, paler below, petioles 1½″. Trees with fawn coloured bark with dark lenticels. Pneumatophores kneed.	TENGAR. *Ceriops Candolleana.*
b.	4″, same colour both sides, petioles ½″ Trees with rough brown fissured bark. Pneumatophores pointed.	PEREPAT. *Sonneratia Griffithii.*
c.	3½″, under surface densely woolly. Often shaped as in 6 (b). Trees with grey smooth bark.	API-API BERBULU. *Avicennia lanata.*
9.a.	6″, alternate, under surface silvery scaly. Small trees without pneumatophores in dry mangrove.	DUNGUN. *Heritiera littoralis.*
b.	3½″ or less, opposite, under surface grey or glaucous. Trees with reddish bark peeling off in papery flakes.	API-API MERAH. *Avicennia intermedia.*
c.	Compound; leaflets 4″, usually 2 pairs, under surface with netted venation; leaves alternate. Trees with dark chocolate-brown very rough bark.	NYIREH BATU. *Carapa moluccensis.*
10.a.	6″, dark green above, white or glaucous beneath, petioles stout. Trees with pendulous branches and grey bark.	API-API HITAM. *Avicennia alba.*
b.	4″, alternate, with brownish scaly undersides suggestive of *durian*. Low shrubs on river banks. Usually as in 2.d.	DURIAN LAUT. *Brownlowia lanceolata.*
c.	4″, alternate, green both sides, petiole slender. Trees with copious milky sap and grey bark with diagonal markings.	BUTA-BUTA. *Excoecaria Agallocha.*
d.	Compound; leaflets 3″, odd paired in 5s or 3s; leaves alternate. Shrubs or climbers with flat single-seeded pods.	SALANG, SETUI. *Derris uliginosa.*
11.	8′ or more, alternate. Bushy trees with milky sap and conspicuous white flowers.	PONG-PONG. *Cerbera spp.*
12.a.	Alternate; flowers scarlet in umbellate clusters. Large trees.	TERUNTUM. *Lumnitzera coccinea.*
b.	Alternate; flowers white in lax racemes. Shrubs or small trees.	TERUNTUM, SESUP. *Lumnitzera racemosa.*



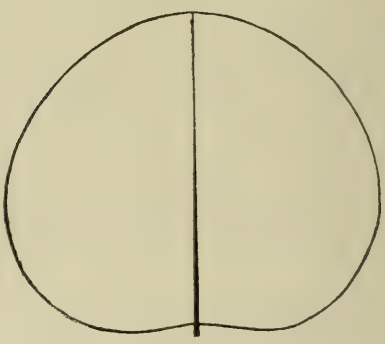
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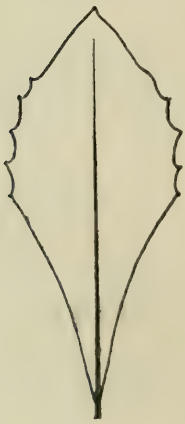
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13.	3″, alternate. Erect shrubs with white flowers and crescent-shaped fruits.	KACHANG-KACHANG. *Aegiceras majus.*
14.a.	5″, alternate, both sides green; petiole as least as long as leaf. Shrubs or small trees with large yellow flowers.	BARU, WARU. *Thespesia populnea.*
b.	5″, alternate, lower surface scaly brown, petiole shorter than leaf. Small trees with inconspicuous flowers.	WALAN (?) *Brownlowia Riedelii.*
15.	4″, alternate, lower surface grey, margin slightly toothed. Shrubs or small trees with large yellow flowers.	BARU, WARU. *Hibiscus tiliaceus.*
16.a.	3″, surface corrugated, same colour above and below. Trees with brown fissured bark and pointed pneumatophores.	GEDABU. *Sonneratia alba.*
b.	Compound; leaflets 2½″, generally two pairs; leaves alternate. Trees with pitted bark and large buttresses.	IPIL. *Intsia retusa.*
17.	2½″, alternate, flaccid. Erect herbaceous shrubs with pink flower heads.	BELUNTAS. *Pluchea indica.*
18.a.	5″, prickly, light green; flowers blue, fruits over 1″. Shrubby herbs with aerial roots. Leaves very variable.	JERUJU PUTEH. *Acanthus ilicifolius.*
b.	As above, darker green; flowers white, fruits under 1″ long.	JERUJU HITAM. *Acanthus ebracteatus.*

The following do not fit the key but are easily identifiable without:—

Fern with large leaves forming dense clumps as illustrated on page 153.		PIAI, LARAT. *Acrostichum aureum.*
Palms (a)	Stemless, entirely unarmed, leaves erect.	NIPAH. *Nipa fruticans.*
(b)	With tall stems armed with sharp spines. Leaves drooping.	NIBONG. *Oncosperma filamentosa.*
(c)	Climbing by means of thorny flagella formed by prolongation of the rachis.	ROTAN BAKAU. *Daemonorops leptopus.*

Chapter III.

BOTANICAL DESCRIPTIONS.

Although the forest characteristics and the key given in Chapter II should enable anyone to identify the species in the field without any difficulty, it is felt that this *Record* would be incomplete were it to allow some of the omissions and inaccuracies in existing botanical descriptions to pass unnoticed. It is, of course, inevitable that in works of the magnitude of Ridley's "*Flora*" and King and Gamble's "*Materials*", there should be gaps, and repetitions of errors on the part of earlier botanists, which could only have been remedied by reference to a far greater number of specimens than were available in the herbaria to which the authors had access.

The exceptional opportunities that frequent inspections in the mangrove reserves afford for first-hand examination and observation of an unlimited quantity of fresh material, and the comparative narrowness of the field of enquiry, should ensure the reasonable general accuracy of the descriptions that follow, at anyrate as far as Malaya is concerned. Only the principal species are included here; the rest are considered to have received sufficient attention in Chapter II.

RHIZOPHORACEAE.

Evergreen trees; usually all parts glabrous; *twigs* swollen at the nodes, terete, with prominent petiolar scars.

Leaves opposite, simple, coriaceous, entire, petiolate; *venation* faint or obsolete, reticulate; *stipules* caducous.

Inflorescence axillary; *flowers* regular, hermaphrodite.

Calyx coriaceous; *tube* adnate to ovary; *lobes* valvate.

Corolla polypetalous; *petals* shorter than calyx lobes, as many as and alternating with them.

Stamens in pairs, inserted with petals at base of calyx lobes.

Ovary more or less inferior; *style* terminal, simple; *ovules* pendulous from the apex of the cell, anatropous, with ventral raphe.

Fruit one-celled, usually one-seeded, indehiscent, girt by the calyx lobes.

Seeds pendulous, viviparous, exalbuminous; *embryo* macropodous.

Extruded radicle large, elongate, perforating the apex of the fruit at the micropyle.

(*i*) Stem supported at the base by numerous stilt-roots; leaves tapering to both ends, mucronate, more or less black dotted on the under surface; calyx 4-cleft; no pneumatophores .. .. .. RHIZOPHORA.

(*ii*) Stem more or less buttressed, rarely with aerial roots; leaves tapering to both ends, not mucronate; calyx 7 to 14-cleft; pneumatophores numerous, sharply kneed with normal bark .. .. .. BRUGUIERA.

(*iii*) Stem buttressed; leaves obtuse or emarginate with narrowed base; flowers small; calyx 5 to 6-partite; pneumatophores kneed with scaly bark .. CERIOPS.

(*iv*) Stem conically thickened at base but not truly buttressed; leaves oblong, obtuse, with narrowed base; flowers conspicuous; calyx 4 to 6-partite; pneumatophores absent .. .. KANDELIA.

(i) RHIZOPHORA Linn.

Stem supported to a height of several feet by very numerous curved, branching, aerial (stilt or flying-buttress) roots; *branches* sometimes supported by similar vertical or columnar roots; *twigs* with prominent stipular and floral scars.

Leaves mucronate, more or less black-dotted below, tapering to each end, glossy, dark green above, paler beneath; *stipules* large sticky, in imbricate pairs, more or less red, interpetiolar, clasping the apex of the twig, and covering the elongated tapering leaf buds.

Calyx 4-lobed almost to the base, thick, surrounded at the base by connate bracteoles; *lobes* acute, thickened at the apex.

Petals white, entire, acute, inserted on a fleshy disk.

Anthers sub-sessile, more or less triangular in section, erect, yellow, multiloculate, opening longitudinally, with small staminodes at base.

Ovary 2-celled, half inferior, projecting above the calyx tube as a fleshy cone; *stigma* bifid; *ovules* 2 in each cell.

Fruit obpyriform, surrounded at the base by the more or less reflexed enlarged calyx lobes, brown, scabrous, not falling with the viviparous seedling.

Extruded radicle terete.

1. Bark deeply horizontally fissured, scabrous, brown or black; leaves distinctly mucronate, always with black dots beneath; inflorescence 2 to 5 flowered; flowers pedicellate; extruded radicle 2 feet or more long, sharp-pointed, bright green, tuberculate .. **R. mucronata.**

2. Bark vertically rather than horizontally fissured, smooth, grey; leaves inconspicuously mucronate, black dots sometimes obsolete; inflorescence 2-flowered; flowers sessile; extruded radicle about a foot long, blunt pointed, smooth, green flushed with red .. .. **R. conjugata.**

1. Rhizophora mucronata Lam.

Tree up to 90 feet high and 5 feet in girth above buttress roots, often developing a straggling or semi-prostrate habit as a result of continuous mutilation or unfavourable conditions.

Stem in closed forest cylindrical with very little taper; *bark* almost black or reddish, scabrous or tesselated, with horizontal fissures almost encircling the stem.

Crown spreading in the open; branches and twigs not directed particularly sharply upwards as is the case with *R. conjugata.*

Leaves up to 8″ by 5″, markedly mucronate, with very distinct black dots on under surface; *venation* faintly visible above, invisible beneath; *midrib* green; petiole more or less 1½″, green, slightly flattened; *stipules* green or pinkish.

Inflorescence. A connately bracted, pedunculate, 2 to 5 usually 3 flowered, somewhat lax cyme, longer than the petioles; *buds* pointed, ovoid, green or yellow, up to 0.75″ long; *flowers* up to 0.9″ across when fully expanded; *pedicels* under 0.5″ long.

Calyx pale yellow or almost white; *lobes* triangular lanceolate, ventrally ridged.

Petals narrowly oblong lanceolate, almost linear, fleshy, lanate, villous along the involute margins; slightly longer than stamens.

Stamens 8, equal, alternately embraced by the petals; *anthers* about 0.35″ long, straight, tapering from base to apex, often mucronate.

Fruit up to 2″ long and 1″ in diameter.

Extruded radicle up to 2 feet or more long, green, warted, up to 1″ in diameter at the widest part which is about ¾ of the way down; gradually tapering to a hard, sharp, point.

2. **Rhizophora conjugata** Linn.

Tree up to 100 feet high and 6 feet in girth above buttress roots.

Stem cylindrical with very little taper; *bark* grey, almost smooth, with shallow vertical furrows or short horizontal fissures, occasionally minutely reticulate (in the form known as *bakau tandok*).

Crown narrow, pyramidal, branches and twigs inclined sharply upwards; frequently supported by columnar roots.

Leaves up to 6″ by 2½″, inconspicuously mucronate, with or without black black dots on under surface; *venation* faintly visible above, invisible beneath; midrib pink or red, rarely green; *petiole* generally less than 1″, red, slightly flattened; *stipules* pink or red, rarely green.

Inflorescence. A 2 flowered ebracteate cyme on a very stout stiffened peduncle in the axils of fallen leaves; *buds* broadly ovoid, reddish when undeveloped, turning green, about 0.4″ long; *flowers* sessile, about 0.75″ across when expanded.

Calyx pale green with small brown bracts; *bracteoles* thickened into a brown, fleshy, globose, roughened cup; *lobes* concave, ovate.

Petals thin, slightly convolute, linear, equal in length to stamens.

Stamens 8 to 14 (Kurz 8/12, King 6/8) one covered by each petal with one or more between; *anthers* similar in shape to and arranged like the sectors of an orange, up to 0.3″ long.

Fruit about 1″ long and half as wide.

Extruded radicle rarely more than a foot long, green with reddish tinge, smooth, glossy, ½″ in diameter, the widest part immediately above the bluntly pointed apex.

(ii) BRUGUIERA Lamk.

Stem more or less normally buttressed or (rarely) supported at the base by short aerial roots and, at least when young, possessing more or less conspicuous corky lenticels; *roots* projecting above the surface of the ground to form numerous sharply kneed pneumatophores; *twigs* encircled by stipular scars.

Leaves acute, not mucronate, tapering to each end; *stipules* large, sticky, in imbricate pairs, green or red, clasping the apex of the twig and covering the elongated tapering leaf buds.

Calyx ebracteate, coriaceous, 8 to 14 lobed.

Petals 2 lobed or emarginate, appendiculate, convolute at the base and embracing the stamens by pairs.

Stamens 2 at the base of each petal; *filaments* usually filiform; *anthers* linear, mucronate, about as long as the filaments.

Ovary inferior, not projecting, 3 celled; ovules 2 in each cell; *style* filiform, 2 to 4-fid.

Fruit 1 celled, 1 seeded, concealed in calyx tube, which crowns and remains attached to the fallen viviparous seedling.

Extruded radicle terete or obscurely ribbed; tip blunt, bearing remains or scar of style.

1. Old bark deeply fissured, brown or almost black, twigs tinged with red; stipular scars broad; petiole generally over 1.25 inches; flowers solitary; calyx bright scarlet with 11 to 14 incurved lobes .. .. **B. gymnorhiza.**
2. Old bark deeply fissured, brown, with conspicuous lenticels up to 2″ across; twigs green, occasionally tinged with red; stipular scars broad; petiole rarely more than 1″, flowers solitary or in twos, usually in threes; calyx pale yellowish or pinkish green with 10 to 12 spreading or reflexed lobes .. **B. eriopetala.**
3. Old bark smooth or slightly rough, not fissured, covered with conspicuous lenticels up to 1″ across; twigs green; stipular scars fine; petiole about 1″ long; inflorescence 1 to 5 usually 3 flowered; calyx green, cut for about half its length into 8 claw-like lobes, sharply reflexed in flower and fruit .. **B. caryophylloides.**
4. Old bark smooth, inconspicuously lenticellate, grey blotched with white; twigs green or yellowish; stipular scars fine; petiole less than 1″, flattened; inflorescence 2 to 5 flowered; calyx elongated, tubular, ridged, with 8 short teeth, remaining permanently attached to the seedling and penetrated by the plumule .. .. .. **B. parviflora.**

1. Bruguiera gymnorhiza Lamk.

Tree up to 120 feet high and 8 feet in girth.

Stem normally buttressed; *bark* lenticellate when young, deeply fissured, thick, brown or almost black when old.

Crown rounded, apt to spread even in closed stand; *twigs* green, tinged with red, stipular scars broad.

Leaves elliptic-acute, tapering to both ends, up to 7″ by 3″, shining dark green above, paler beneath; *venation* invisible or faint above; *midrib* reddish; petiole usually over 1½″ more or less terete, upper half grooved on ventral surface; *stipules* red.

Flowers solitary; buds fusiform up to 1½″ long, green when young, becoming scarlet before opening; sutures of calyx lobes clearly defined.

Calyx thickly coriaceous, narrowly campanulate, scarlet outside white inside, divided for about half its length into 11 to 14 lobes; *tube* obscurely angled; *lobes* narrow, tapering, sharply pointed, ventrally ridged, sub-erect.

Petals stiff, almost pergamentaceous, white, turning brown, as many as and shorter than calyx lobes, about 0.6″ long, oblong, bi-partite, bearing on the apex of each lobe 2 (sometimes 3) hair-like appendages, with a thick bristle in the sinus and silky hairs along the lateral margins especially at the base.

Stamens in pairs; *filaments* about ½ inch long, white; *anthers* linear, basifixed.

Style about 1″ long, projecting beyond petals, but not beyond calyx lobes; *stigma* usually 4-fid.

Fruiting calyx campanulate, teeth incurved, remaining temporarily attached to the fallen seedling.

Extruded radicle cigar-shaped, up to 6″ long, smooth, slightly ribbed or angled, green turning bronze colour when ready to fall.

2. **Bruguiera eriopetala** Wight.

Tree up to 90 feet high and 7 feet in girth.

Stem normally buttressed or with short aerial prop-roots; *bark* lenticellate when young; deeply fissured, thick, greyish brown or reddish when old, with conspicuous corky lenticels up to 2″ across particularly on the buttresses.

Crown inclined to spread, but less so than the preceding species; *twigs* green, occasionally tinged with red, stipular scars broad.

Leaves elliptic acute, tapering to both ends, up to 6″ by 2½″, colour and venation as for *B. gymnorhiza*; *midrib* green; *petiole* about 1″ long, slender, grooved on ventral surface for most of its length; *stipules* green or pinkish.

Inflorescence a 3 flowered pedunculate cyme, or in pairs, or solitary; *peduncles* about 0.4″ long; *buds* up to 0.9″ long, yellowish or pinkish, the sutures of the lobes clearly defined.

Calyx thickly coriaceous, campanulate, yellow or pinkish, rarely scarlet, divided for about half its length into 10 to 12 lobes; *tube* obscurely angled; *lobes* narrow, tapering, sharply pointed, ventrally ridged, divergent.

Petals similar to *B. gymnorhiza* except for size; number of appendages on lobes usually three, sometimes two.

Stamens about as long as petals; *filaments* white, the outer slightly longer than the inner and kinked below the anthers.

Style straight, slender, projecting beyond the petals; *stigma* usually 2-fid.

Fruiting calyx campanulate, teeth slightly recurved, remaining temporarily attached to the fallen seedling.

Extruded radicle cigar-shaped, terete or obscurely ribbed, smooth, green, not usually exceeding 3″ in length.

B. eriopetala is a very variable species with characters intermediate between *B. gymnorhiza* and *B. caryophylloides*, even to the extent of habitat. It is suggested that it may be a cross between those two species. It is quite wrong to describe it as the commonest species (Ridley's *Flora*, p. 695). Though it is common enough in some places it is, on the whole, the rarest.

After examining a large number of specimens the writer has come to the conclusion that the petals of *B. gymnorhiza* and *B. eriopetala* exhibit no constant differences, that they are equally woolly, that the bristle in the sinus is common to both, and that the appendages on the lobes may number 2 or 3 in either case, though they are usually as stated above. The only safe guides to identification are the relative sizes of the flowers and the lenticellate bark of *B. eriopetala*. The colour of the calyx is by no means infallible, both yellow *B. gymnorhiza* and bright scarlet *B. eriopetala* having been collected.

3. **Bruguiera caryophylloides** Blume.

Tree up to 70 feet high and 3½ feet in girth.

Stem shortly and acutely buttressed; *bark* markedly lenticellate at all ages, smooth, greyish.

Crown dense, pyramidal; *twigs* green, slender, stipular scars fine.

Leaves elliptic acute, tapering to both ends, up to 5″ by 2″ but usually much smaller, dark green above, paler beneath; *venation* faintly visible above, invisible beneath; *midrib* green; *petiole* about 1″ long, terete, grooved for most of its length on ventral surface; *stipules* green.

Inflorescence a laxly 1 to 5 usually 3 flowered erect cyme, generally not longer than the petiole; *peduncles* up to 0.5″ long; *bracts* minute; *buds* green, about 0.4″ long, bluntly conical, narrowed to base; *flowers* about 0.45″ long and 0.3″ in diameter when fully expanded.

Calyx thickly coriaceous, green; *tube* turbinate-clavate, not ribbed, rounded at base; *lobes* 8, about as long as tube, claw-like, sharply reflexed.

Petals membranous, white, oblong, bifid, with a single bristle in the sinus and 3 short twisted appendages on each lobe; lateral margin slightly hairy on outer side.

Stamens in pairs, one behind the other; *filaments* white, tapering, the shorter inside; *anthers* brown, pointed.

Style filiform, projecting slightly beyond anthers; *stigma* bifid.

Fruiting calyx star-shaped, urceolate, lobes strongly reflexed, temporarily adherent to the fallen seedling.

Extruded radicle up to 6″ long, about as thick as a lead pencil, green turning brownish when ready to fall, terete, narrowed at both ends, curved, surface minutely rugulose.

4. **Bruguiera parviflora** Wight.

Tree up to 70 feet high and 2½ feet in girth.

Stem normally buttressed; *bark* not noticeably lenticellate, smooth, grey, blotched with lighter patches.

Crown rather narrow, somewhat rounded, yellowish green; *twigs* yellow glabrous, slender, sometimes striate; *stipular scars* fine, brown.

Leaves elliptic-lanceolate, tapering to both ends, up to 6″ by 2″ but usually much smaller, usually but not invariably yellowish; *venation* faintly visible on both sides when dry; *petiole* rarely as much as 1″ long, somewhat flattened, ventrally grooved for its whole length; *stipules* pale green.

Inflorescence a 2 to 5 flowered cyme, as long as or longer than the petioles; *peduncle* 0.4″ long, flattened; *bracts* 2, membranous, at the top of the peduncle, up to 0.5″ long, the bases turning brown, more or less persistent; *flowers* about 0.5″ long; *buds* 0.4″ long, yellow-green, cylindrical, tapering towards the base, the unopened calyx lobes forming a short conical top.

Calyx chartaceous, yellowish; *tube* cylindrical, ribbed, adnate to base of ovary; *lobes* 8, very short, erect, valvate, rigid, acute, less than one quarter the length of the tube.

Petals yellow, oblong, minute, the apex broad, emarginate, bearing in the sinus 1, and on the edge of each lobe about 3 slender white appendages; lateral margins minutely hairy.

Stamens in pairs, one behind the other; *filaments* pale yellow, the longer outside and as long as the petals; *anthers* brown, sagittate, about as long as the filaments.

Style short; *stigma* bifid or trifid.

Fruiting calyx cylindrical, tubular, ribbed, about 0.9″ long, permanently adherent to and closely embracing the top of the fallen seedling.

Extruded radicle up to 9″ long, slender, thinner than a lead pencil, straight, bright green, not changing colour when ready to fall, terete, slightly narrower at both ends but cylindrical for most of its length; tip blunt, recessed; upper portion enclosed in calyx tube, which is subsequently pierced by the plumule.

(iii) CERIOPS Arn.

As only one species is known to occur in the Malayan swamps a separate description of the characteristics of the genus would be superfluous. *C. Roxburghii* was credited to the peninsula by King (27), but though careful search has since been made it has never been collected and is, therefore, rightly excluded from Ridley's *Flora*.

Ceriops Candolleana Arn.

Tree up to 80 feet high and 4½ feet in girth, often degenerating into a bushy shrub in unfavourable localities.

Stem with fluted buttresses up to a height of 3 feet or more, moderately straight, apt to fork; *bark* pale brown, smooth, occasionally flaked or slightly scabrous on old trees, conspicuously lenticellate. Aerial roots have never been seen or reported in the peninsula*.

Crown dense, dark, rounded; twigs green, lenticellate, scurfy. Columnar branch-roots have never been found locally*.

Leaves clustered at the ends of the twigs, obovate-oblong, almost exactly twice as long as broad, 4″ by 2″ or smaller, blunt or slightly retuse, narrowed at base, margin often wavy or irregular, dark green above, paler beneath; *venation* faintly visible above, invisible below; *midrib* prominent on both sides; *petiole* 1.25″ or more, terete.

Inflorescence a 4 to 10 flowered, branched, pedunculate cyme, with minute, connate, bracts and bracteoles; *peduncle* up to 0.75″ long, flattened on the upper side; *pedicels* less than 0.25″; *flowers* fragrant, about 0.25″ long in bud and the same in diameter when fully expanded; *buds* ovoid, 5 angled, green.

Calyx divided for more than half its length into 5 triangular sub-acute, green, thickly coriaceous lobes; *bracteoles* connate at base of tube.

Petals white, turning brown, oblong-obovate, apex truncate with three short appendages.

Stamens 10, alternately enclosed by petals and about the same length; *filaments* white, filiform, inserted between the lobes of an annular disk; *anthers* sagittate, introrse, dorsifixed.

Ovary half inferior, 3 celled, 2 ovules in each cell; *style* tapering, almost as long as ovary, grooved; *stigma* 3-fid.

Fruit obpyriform, up to 1″ long, brown, scabrous, adnate to the enlarged and flattened calyx tube and girt at the base by the horizontally spreading lobes.

Extruded radicle up to 12″ or more in length, dark green, rugulose, conspicuously ridged and warted, sharply pointed, slender at the neck and thickening to a maximum of about 0.4″.

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* See page 46.

(iv) KANDELIA Wight & Arn.

This genus has but a single species, viz:

Kandelia Rheedii W. & A.

Small tree, rarely as much as 20 feet high, often shrubby.

Stem conically thickened at base; *bark* smooth, lenticellate, reddish brown on stem, pale and flaky at base.

Branches inclined upwards at a sharp angle; *twigs* stiff, slender, pinkish.

Leaves clustered at ends of branches, oblong, more than twice as long as broad, about 4″ by 1.25″, margins reflexed, apex blunt, tapering to base, bright green above, paler beneath; *venation* faintly visible above, invisible beneath; *petiole* stout, about ½″ long, flattened but not grooved; stipules green, spirally twisted and enveloping bud like an auger point.

Inflorescence dichotomously branched, usually 4 flowered, suberect; *peduncles* up to 2″ or more; *pedicels* about 0.2″; *bracteoles* coriaceous, connate into a small toothed cup suggestive of a calyx tube; *buds* cylindrical with tapering apex and expanded base.

Calyx white, petaloid; *lobes* valvate in bud, 4 to 6, about 0.6″ long and 0.1″ wide, linear lanceolate, sharply reflexed for about five sixths of their length.

Petals inconspicuous, about half the length of the calyx lobes and alternating with them, white, sometimes tinged with pink, bifid, each lobe ending in a number of capillary attachments, with a single one in the sinus.

Stamens perigynous, indefinite; *filaments* varying in length, all somewhat shorter than calyx lobes, white, slender, erect, forming a brush around the style; *anthers* small, pink.

Ovary sunk in the calyx tube, prolonged into a cone as in Rhizophora, 1 celled; *ovules* 6; *style* filiform, stiff, somewhat shorter than stamens; *stigma* 3-fid.

Fruit obpyriform, leathery, about an inch long and one half as wide, green, covered with brown scales, the base enclosed by the adnate enlarged calyx tube and girt by the persistent reflexed calyx lobes.

Extruded radicle usually solitary, but occasionally two or more from the same fruit, glabrous, bright green, terete, widest towards the tip, tapering to a very sharp point, up to 16″ long with a maximum width of 0.35″.

VERBENACEAE.

This is a very variable order. As it is represented in the mangrove by a single genus (Avicennia) which exhibits many un-typical features a separate description of the characters of the order is unnecessary.

AVICENNIA Linn.

Trees, usually medium sized but occasionally large.

Leaves opposite, coriaceous; *petioles* short, stout, almost encircling twigs.

Inflorescence bracteate, capitate or spicate; *flowers* sub-regular.

Calyx coriaceous, 5 lobed, not enlarged in fruit; *lobes* imbricate, margins minutely ciliate.

Corolla 4 lobed, campanulate, yellow, sub-equal.

Stamens 4, alternate with corolla lobes.

Ovary superior, imperfectly 4 celled; *ovules* 4; *style* bifid.

Fruit a leathery, 2 valved, usually gibbous capsule containing a single viviparous seed.

Pneumatophores small, numerous, asparagus-like.

It is remarkable that, in spite of well marked differences between the different forms, most botanists should have recognised only one or at most two distinct species, viz: *A. officinalis* and *A. alba*. Prain (39) admitted the occurrence of both species in the Sundribuns, but though he remarked on the existence of other local forms he did not consider them worthy of specific rank. Hooker (25) describes *A. alba* as a variety of *A. officinalis*, but the absence of details suggests that his material was scanty. Kurz (28) mentions *A. officinalis* L., and *A. tomentosa* Roxb., but his description of the latter agrees with that usually accepted for the former, whilst his description of the former suggests *A. alba* Bl., except that he mentions that the leaves may be obovate. It seems not at all unlikely that sterile specimens of *A. intermedia* Griff. may have been included amongst his material. It is noteworthy that Kurz makes a special point of capitate and spicate inflorescences, characters that apparently escaped the attention of other botanists.

Brandis (4) describes only *A. officinalis* and keeps out of danger by giving only a very cursory description of the capsule. Though he mentions *A. alba* he makes no comment thereon. Gamble (27) describes both species, but there are inconsistencies that suggest

that his material was mixed. Engler and Prantl include only *A. officinalis* as a native of tropical Asia. Koorders describes *A. officinalis* as a polymorphic species and, though *A. alba* Bl. is mentioned, and more or less accurately described, it is not considered to be anything more than a variety. Schimper (47) is content to regard *A. officinalis* as "a regular Proteus, that is even more polymorphic than Rubus and Hieracium."

A serious effort appears to have been made by Griffith (*Posthumous Papers* 1854, part IV., p. 185) to clear up the confused descriptions in the botanical works then extant, with particular reference to the Malayan forms. He mentions three forms as occurring in the neighbourhood of Malacca, viz: *A. resinifera*, which appears to correspond in every respect with *A. alba* Bl.; *A. intermedia*, which he suggests may be a hybrid; and *A. obovata*, which fits *A. officinalis* L. (except for the spicate inflorescence) but which Griffith himself identifies with *A. tomentosa* Roxb.

Ridley (42) recognises 5 species, his descriptions agreeing essentially with those that follow this note. I was fortunate enough to be able to discuss the species with Mr. Ridley before the M.S. of this part of his *Flora* had been sent to the printer. He had arrived independently at the conclusion that there were four distinct Malayan species, but he had overlooked *A. lanata*, whilst I had not seen *A. sphaerocarpa*. The result has been the admission of 5 distinct species for Malaya, but it is suggested that the existence of the last named requires further confirmation before it can be accepted.

The following are the more noticeable differences:—

1. Bark grey, not flaking; leaves oblong or elliptic, symmetrical, apex rounded, margins slightly reflexed, greyish below; inflorescence capitate; flowers ½″ or more across; fruit 1″ or more long, covered with russet tomentum .. .. A. officinalis.
2. Bark grey, not flaking; leaves oblong or obovate, sometimes sub-acute, symmetrical, margins not reflexed, the under surface covered with dense fawn-coloured flannel-like tomentum; inflorescence capitate; flowers small; fruit ½″, blunt, pale green, densely woolly .. .. .. A. lanata.

3. Bark red, peeling off in papery flakes exposing green inner bark and suggestive of Guava; leaves acute, obtuse, or rounded, often asymmetrical, margins wavy or undulating, under-surface whitish or glaucous; inflorescence more or less capitate; flowers small; fruit ½″, mucronate, pale green, tomentose but not woolly .. .. **A. intermedia.**
4. Bark grey, not flaking ; leaves lanceolate, acuminate, symmetrical, margins not reflexed, underside white or glaucous; inflorescence spicate, flowers small; fruit 1″ or more long and only half as wide, acuminate, pale green, transversely wrinkled .. **A. alba.**
5. Description incomplete; occurrence doubtful **A. sphærocarpa.**

1. Avicennia officinalis Linn.

Tree up to 60 feet in height and 5 feet in girth.

Stem not buttressed, bole usually short; *bark* grey, slightly fissured, lenticellate, thin.

Crown bushy; *twigs* terete, sometimes striate, brown, glabrous, slightly lenticellate.

Leaves oblong or elliptic, up to 4″ by 2½″, symmetrical, apex nearly always rounded, base cuneate, margin entire, slightly reflexed, bright shining green above, glabrous or covered partly or entirely beneath with very fine pale tawny tomentum which, however, does not include the midrib; *venation* in fresh material faint above, fairly distinct beneath, *vice-versa* when dry, the reticulations then becoming distinct; *midrib* depressed above; *petiole* ½″ or less, stout, flattened.

Inflorescence capitate, few flowered; *peduncles* terete or striate, slightly lenticellate, pale green with very fine tomentum.

Corolla tube shorter than lobes, the expanded flower ½″ or more in diameter, lemon yellow.

Stamens excerted; *anthers* reniform; *filaments* very much longer than anthers, up to ⅛″ long.

Style long, slender, tapering; stigmatic lobes erect.

Fruit compressed ovoid, gibbous, slightly beaked, 1½″ long and 1″ wide, covered with tawny velvety tomentum; hairs of radicle tawny, not hooked.

2. **Avicennia lanata** Ridley.*

Tree up to 100 feet in height and 10 feet in girth, but usually very much smaller.

Stem not buttressed, cylindrical, with a straight bole in closed stand; bark dark grey, smooth.

Twigs terete, quadrangular, covered when young with dense tawny tomentum.

Leaves ovate or elliptic, occasionally sub-acute, about 4″ by 2½″, tapering abruptly to base, symmetrical, entire, margins not reflexed, coriaceous, dark green above, covered with dense, flannel-like, slightly tawny tomentum beneath; *midrib* prominent beneath, covered with tomentum like rest of underside of leaf; *petiole* about ¾″, comparatively slender, not conspicuously flattened.

Inflorescence in three-branched cymose heads, all parts densely tomentose; *peduncles* quadrangular; *flowers* small, fragrant.

Corolla glabrous inside, densely hairy outside; *lobes* strongly reflexed.

Stamens half excerted; *anthers* elliptic, same length as filaments.

Style short; stigmatic lobes divergent.

Fruit broadly ovoid, compressed, gibbous, not more than ¾″ in length, as broad as long, covered with dense woolly tomentum; hairs of radicle tawny, not hooked.

3. **Avicennia intermedia** Griffith.

Small tree, rarely more than 40 feet high and 3 feet in girth.

Stem usually contorted, often forked; bark smooth, thin, reddish brown, falling in papery flakes and exposing green inner bark, suggestive of *Carapa obovata* or Guava.

Crown very light; twigs distinctly quadrangular.

Leaves acute, obtuse, or rarely rounded, not usually exceeding 3½″ by 1½″, base cuneate, often asymmetrical, margin entire, often undulating, yellowish green above, lower surface (including the midrib) covered with silvery grey or glaucous, very short, closely adpressed tomentum; *venation* faint below, distinct above, particularly when fresh; *midrib* prominent beneath; *petiole* not usually more than ½″, slender.

Inflorescence more or less capitate; peduncles distinctly quadrangular, often striate, with sparse pale green tomentum; expanded flower up to ¼″ in diameter.

Corolla pale yellow; *tube* equal in length to lobes; *lobes* recurved.

Stamens half excerted; *anthers* triangular-reniform; *filaments* very short.

* Found only in Singapore and on the east coast.

Style short, stout; stigmatic lobes erect.

Fruit compressed, ovoid, not gibbous, about ½″ long, with short point, pale green, indistinctly silvery tomentose, slightly rugulose; hairs of radicle white, not hooked.

4. **Avicennia alba** Blume.

Tree up to 70 feet high and 4½ feet in girth.

Stem not buttressed; bark smooth, grey.

Crown spreading, the main branches often covered with sooty rust fungus; *twigs* glabrous, terete, pendulous.

Leaves lanceolate-acuminate, dark shining green above, white or glaucous beneath, up to 5″ by 2″, narrowed to base; *venation* visible above and below; *petiole* stout, flattened, up to ¾″ long.

Inflorescence spicate, up to 3″ or more long; *peduncles* terete, tawny, tomentose; *flowers* up to 0.25″ in diameter, orange yellow, fœtid.

Corolla orange yellow; *lobes* slightly reflexed, same length as tube.

Stamens inserted; *filaments* stout, about the same length as the ovate anthers.

Style short, stout; stigmatic lobes reflexed.

Fruit acuminate, gibbous, more or less beaked, transversely wrinkled, yellowish green, indistinctly silvery tomentose; hairs of radicle white, distinctly hooked.

5. **Avicennia sphaerocarpa** Stapf.

The following description is taken from Ridley's "*Flora of the Malay Peninsula.*"

> Small tree. Leaves elliptic narrowed to top or round, base narrowed whitish beneath, 3 in. long, 1.5 in. wide; petioles winged above, 0.25 in. long. Inflorescence axillary of 2 to 3 or more flowers terminal on peduncles 0.3 to 0.75 in. long, puberulous. Calyx lobes oblong ciliate, silky, 0.15 in. long. Corolla not seen. Fruit globose, not beaked, 0.75 in. long. *Hab.* Penang, Sungai Pinang (Curtis). *Distrib.* Siam, Phillippines, China.

I have no hesitation in identifying specimen No. 3533, collected by C. Curtis at Sungai Pinang in 1900 as *A. intermedia* Griff.

LYTHRACEAE.

The genus Sonneratia is the only representative of this order in the mangrove swamps; a separate description of the order would, therefore, be superfluous. The characters of the genus are:

SONNERATIA Linn. fil.

Trees, evergreen, all parts glabrous.

Leaves opposite, simple, entire, coriaceous, exstipulate; *venation* faint.

Sonneratia.—(*Contd*).

Inflorescence conspicuous, 1 or few flowered; *flowers* large, regular, hermaphrodite.

Calyx inferior, free, coriaceous; *tube* campanulate; *lobes* 6 to 8, valvate, triangular, acute.

Petals linear oblong, membranous, as many as calyx lobes or none.

Stamens indefinite, unequal, inserted singly on a disk at the base of the calyx lobes, folded inwards in bud like a ball of worsted, excerted in flower, fugacious; *filaments* filiform, tapering towards the apex, free, erect, unequal; *anthers* small, basifixed, reniform, ventrally ridged, laterally flattened, pale yellow, two celled, dehiscing at the top longitudinally.

Ovary free, or nearly so, sunk in the calyx tube, sessile, flattened above, many celled; *placenta* thick, axile; *ovules* numerous, ascending, anatropous; *style* longer than stamens, simple, terete, stout, doubly folded over the stamens in bud, excerted beyond them in flower; *stigma* capitate.

Fruit a more or less depressed, globose, many celled, many seeded capsule, supported on or partly embraced by and more or less adnate at the base to the persistent calyx, green or yellowish, fleshy or coriaceous, indehiscent, surmounted by the remains of the style; *seeds* immersed in pulp, angular, small; *testa* coriaceous.

Pneumatophores large, conical.

As pointed out by Parker (37), there are such wide discrepancies in the descriptions of the species belonging to this genus, that the identifications depend almost entirely on the flora used. This is, no doubt, largely due to the impossibility of satisfactorily preserving the mature fruit attached to the dried leaf specimens, and to the fragility of the flowers; but it also seems likely that there are local variations that make it extremely difficult to fix definite stable characters, and which may even necessitate the creation of new species.

Three distinct forms are recognised in the Malay peninsula, but none of them can be said to fit very closely with any of the available published descriptions. The form known as *berembang* seems to fit Parker's *S. caseolaris**, whilst that known as *perepat* can be reconciled with his description of *S. alba*. But if the titles on the excellent illustrations of Brown and Fischer (6) are to be followed, Parker's names will have to be reversed. Ridley (42) follows King (17) in crediting *S. Griffithii* with obovate leaves narrowed to the base, and *S. alba* with obovate-reniform leaves decurrent on the

* The specific name refers to the shape of the fruits.

petiole, but neither of these authors makes any mention of the rounded or almost cordate leaf bases and ovate or orbicular leaves, the rugose ridged calyx, and the edible fruits, that are such distinctive features of the form known as *gedabu*. They also neglect the carmine throated spreading calyx and the comparatively small inedible fruits of *perepat*. These characters are brought out very distinctly in the illustrations in Chapter II.

If follows, therefore, that it has not been possible to reconcile the three Malayan forms with any of the published descriptions. This difficulty has been accentuated by the careless use of the vernacular names which, in the experience of the writer, have always proved reliable in the field. For this reason, the botanical and vernacular names are bracketed together. The native names given by Ridley (42) must be entirely disregarded, and it should be clearly understood that the botanical names that follow have been adopted for the sake of convenience, and not because they are considered to be necessarily correct.

The most distinctive features of the three forms are:

1. Twigs slender, pendulous; leaves lanceolate, dark green with crimson base and midrib, sessile; flowers purple; fruit up to 3″ in diameter, flattened, dark green, juicy, edible, seated on flat or reflexed calyx .. **S. acida.** (*Berembang*).

2. Twigs stiff; leaves obovate, narrowed to base, light green, venation indistinct; flowers white; fruit rarely up to 2″ in diameter, almost globular, with concave depression surrounding the persistent style, bright green, hard, not edible, enclosed at base by calyx tube and surrounded by spreading star-shaped carmine-throated calyx lobes which project far beyond it .. **S. Griffithii.** (*Perepat*).

3. Twigs stiff; leaves orbicular or reniform, cordate or rounded at base, dark green, surface corrugated, petiole distinct, venation distinct; flowers white; fruit 2″ or more in diameter, less flattened than (1), yellowish, turgid, edible, closely embraced by the ribbed rugulose calyx lobes .. .. **S. alba.** (*Gedabu*).

1. **Sonneratia acida** Linn.

(*Berembang.*)

Tree up to 70 feet high and 5 feet in girth, usually smaller.

Stem not buttressed, usually short boled; *bark* smooth, grey, lenticellate when young, light brown, thick, irregularly fissured when old.

Crown rounded, spreading, not dense; *twigs* yellowish, pendulous, giving the tree the general appearance of a willow.

Leaves lanceolate, apex acute, sessile or nearly so, about 3½" by 1½", dark green above and below, base and lower part of midrib crimson; *venation* faint on both sides.

Inflorescence terminal, 1 flowered, ebracteate; *peduncles* jointed, terete or obscurely quadrangular; *flowers* purple, sickly-sweet smelling; *buds* sub-globose with acute apex, slightly narrowed below the sutures of the calyx lobes, about 1.3" long and 0.9" wide.

Calyx 6 rarely 7 or 8 toothed for rather more than half its length; *tube* smooth, not ribbed; *lobes* smooth, the inner surface pale yellow sometimes streaked with carmine.

Petals membranous, delicate, inserted at base of, alternating with, and about as long as calyx lobes, dark purple, narrowed at the base, tapering to a point at the apex, about 0.1" wide.

Stamens conspicuous; *filaments* up to 2.4" long, carmine below, shading off into white above.

Style up to 3" or more in length; *stigma* grooved at apex.

Fruit up to 3" across, less than half as high, dark green, seated on the calyx tube, crowned with the enlarged conical base of the style, edible and of the consistency of an unripe pear; *fruiting calyx* concave from below, smooth, green, with more or less horizontally spreading lobes.

2. **Sonneratia Griffithii** Kurz.

(*Perepat.*)

Tree up to 120 feet high and 7 feet or more in girth.

Stem cylindrical, not buttressed, with clean, straight bole in closed forest, contorted in the open; *bark* brown, thick, fissured.

Crown rounded, contorted, not dense; *branches* short; *twigs* stiff, terete, grey or greenish, swollen and brittle at the nodes.

Leaves obovate, rounded or retuse at apex, cuneate at base, up to 4½" by 3", pale green above and below; *venation* faint above, almost invisible below; *midrib* prominent below; *petiole* short, stout, not more than ½" long.

Inflorescence terminal, generally one flowered, occasionally a 2 or 3 flowered cyme; *flowers* white; *bracts* 0; *peduncles* stout, terete, green, about 1" long; *buds* oblong, ellipsoid, tapering to

each end, very slightly ridged, up to 1.5″ long and about half as wide; *pedicels* stout, jointed.

Calyx lobes usually 6, sometimes 7, rarely 8, rather longer than the tube, carmine inside.

Petals absent or vestigial, white.

Filaments white, about 1.5″ long.

Style 2″ or more long; *stigma* more or less dented at apex.

Fruit up to 2″ in diameter, almost globular, more or less flattened or depressed above, the base enclosed by the persistent calyx tube, green, hard, inedible, surmounted by conical base of the style; *fruiting calyx* obscurely ribbed, smooth, green, with obconical tube, the lobes spreading beyond the ripe fruit.

Pneumatophores large, conical, up to 2 feet high but usually smaller, those of the young trees being asparagoid and, when partially covered with mud, easily confused with Avicennia.

3. **Sonneratia alba** Smith.

(*Gedabu.*)

Tree, up to 80 feet high and 6 feet in girth, but usually very much smaller.

Stem usually contorted, with short bole; *bark* brown, fissured.

Crown rounded, dense; *twigs* stiff, brittle, swollen at nodes.

Leaves orbicular, reniform, or broadly ovate, with rounded or cordate base, up to 4″ by 4″, dark green above and below, surface corrugated; venation fairly obvious on both sides; petiole ½″.

Inflorescence rarely one flowered, usually a 2 to 5 flowered cyme, terminal or axillary; *bracts* caducous, resembling small foliage leaves; *peduncles* terete or obscurely quadrangular, sometimes jointed; *flowers* white, sickly sweet smelling; *buds* about 1.1″ long and 0.75″ wide, ellipsoid, papillose, constricted in the middle and tapering at the base to a false pedicel; *pedicels* terete or subquadrangular.

Calyx lobed for about half its length; *tube* ribbed; *lobes* usually 6, carmine-tinted at the base.

Petals absent or vestigial, white.

Filaments white, about 1½″ long, sometimes tinged with pink.

Style seldom 2″ long; *stigma* more or less dented at apex.

Fruit up to 2½″ across, more than half as high, when ripe yellowish, fleshy, turgid, edible with quince-like flavour, persistent style entire and not thickened at base; *fruiting calyx* rugulose, ribbed alternately with the lobes, closely embracing the base of the fruit.

Pneumatophores as for (2) covered with dark, scaly, bark.

MELIACEAE.

This order is represented in the mangrove by a single genus, viz:

CARAPA Aubl.

Trees, all parts glabrous.

Leaves alternate, compound, paripinnate; *leaflets* opposite, usually 2 pairs, dark shining green with almost invisible venation above, pale green with obvious reticulations and prominent midrib beneath; *petiolules* 0.25″ or less, swollen; *petioles* swollen at base, leaf scars distinct.

Inflorescence axillary, sometimes produced on older branches, panicular, insignificant; *flowers* small, yellowish or pinkish.

Calyx 4 lobed.

Petals 4; *stamen-tube* urceolate, 8 denate.

Stamens 8, included, inserted on a fleshy cup-shaped disk, alternating with teeth of tube.

Ovary superior, 4 celled; *ovules* 2 to 8 in each cell; *style* short; *stigma* discoid.

Fruit large, globose, 4 celled, with leathery pericarp dehiscing by 4 valves; *seeds* large, not embedded in pulp, numerous, irregularly pyramidal with rounded base; testa soft, spongy.

There are two mangrove species*, regarding which considerable confusion exists in botanical works. The most adequate descriptions are those of King (27), except that the fruits are reversed. Hooker (25) only mentions one species; Brandis (4) gives rather meagre descriptions, but correctly emphasises the difference in leaf consistency and the comparative size of the fruits; Kurz (28) generally agrees with King, but credits *C. moluccensis* with a 5-cleft calyx and corolla; Ridley (42) does not mention the consistency of the leaf of *C. obovata*, and has got the fruits reversed, whilst his description of the bark of *A. moluccensis* as "flaky" rather suggests the other species.

The truth is that identifications from dried specimens are not entirely reliable, the chief distinguishing features being the bark and fruits. The consistency of the leaves is a not entirely safe guide, the membranous nature of *C. moluccensis* being brought out by but depending largely on the manner of the drying. Trees of this species have been seen growing under abnormal conditions on the beach at Pulau Seribuat (Pahang), the leaves of which were succulent and at least a tenth of an inch thick.

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* Specimens suggesting Pierre's *Carapa* (*Xylocarpus*) *mekongensis* have been collected in Johore and Pahang, but in both cases well above the mangrove limit.

1. Carapa obovata Blume.

Tree up to 60 feet high and 6 feet in girth.

Stem buttressed, usually contorted, often hollow; *bark* thin, smooth, pale reddish brown, falling in papery flakes and exposing green inner bark.

Crown bushy, distorted; *twigs* slender, brown, lenticellate.

Leaflets coriaceous, elliptical or obovate, tapering to base, apex round or obtuse, symmetrical, margin slightly reflexed, 4″ by 2″ or less.

Inflorescence cymose, much branched, spreading, under 2″ long; *peduncles* stout; *buds* green, ovate, tapering to base, 0.25″ long; *pedicels* less than 0.1″; *flowers* 0.2″ long, 0.5″ in diameter.

Calyx trumpet-shaped, tinged with red, 0.2″ long, cut for about one fourth its length into 4 broadly acute teeth.

Corolla lobes 4, white, spreading, alternate with calyx lobes, broad, oblong, apex rounded; *staminal tube* urceolate, 0.2″ long, tinged with pink particularly at base, teeth obtuse and about one fourth the length of the tube.

Ovary bright orange yellow.

Fruit globose, as large as a pomelo, brownish when ripe.

Pneumatophores not present, but surface roots are knife-edged and project above the surface of the mud.

2. Carapa moluccensis Lam.

Tree up to 80 feet high and 10 feet in girth.

Stem buttressed, often with good straight bole, but frequently hollow; *bark* dark chocolate brown, thick, deeply fissured, imbricate.

Crown narrow, compact.

Leaflets sub-coriaceous or sub-membranous, irregularly elliptical, base unequal, tapering or obtuse, apex obtuse or rounded, margins not reflexed often wavy, 4″ by 2″, rather larger than (1).

Inflorescence racemose, usually more than 3″ long, many flowered; *peduncles* slender; *buds* white, ovate, 0.15″ long; *flowers* 0.2″ long, 0.5″ in diameter when expanded.

Calyx as for (1); lobes rounded, white. (Kurz says 5 lobed).

Corolla as for (1); *staminal tube* cut for about one fifth its length, teeth broadly acute.

Ovary bright crimson.

Fruit obscurely 4-sided, as large as a medium sized orange, irregular, brownish.

Pneumatophores present in the shape of finger-like projections or crests from the knife-edged surface roots, often extending up the buttresses.

Chapter IV.

SILVICULTURE.

(*a*) The Distribution of the Species.

Although it would be unwise to generalise too freely from local experience there can be no doubt that the unpleasantness and supposed inaccessibility of the interior of mangrove swamps have led to some very faulty observations and deductions on the part of ecologists who have otherwise been remarkable for the accuracy of their notes and the soundness of their reasoning. When, as recently as 1901, a proposal that reconnaisance lines should be cut through the swamps could be successfully countered by the local (Perak) forest officer with the remark that the man who made the suggestion (no less an authority than Mr. H. C. Hill who soon afterwards became Inspector General of Forests, India!) ought to have known that he was asking the impossible, it is perhaps not surprising to find the following passage committed to paper by Warming (51. p. 236).

> "Furthest out towards the sea are those that are best capable of fixing themselves in deep water, namely species of Rhizophora; within these, in shallower water or on dryer ground, succeed those species that have smaller capabilities in this respect, namely species of Avicennia, Bruguiera, Aegiceras, and others. .....In as much as Rhizophoraceae form the outposts of the mangrove they entangle mud between their roots and thus add to the land."

Schimper (46) and Haberlandt (22) assert that *Rhizophora mucronata* forms an advanced line along the sea, where it resists the action of the waves, the latter describing in some detail the perfection of its adaptation for this particular purpose. These remarks have been quoted by a number of other authors, who have made similar unfortunate generalisations with regard to the distribution of other species, more particular Avicennia.

Such misconceptions are, no doubt, largely attributable to the abnormal conditions obtaining around Singapore island, where the swamps partake of the characters of both east and west coast forms, and where for very many years there have been the added complications of chronic over-exploitation and constant interference with the drainage. Singapore is essentially a deep-water port, whilst the island is separated from the mainland of Johore by a comparatively narrow and deep channel with a pronounced tidal scour.* It is in the less disturbed and much more extensive areas bordering the Straits of Malacca, away from harbour works and deep water, that normal conditions are more likely to prevail, and it is here that the species are likely to find their proper level.

* The causeway is likely to have far-reaching effects on the mangrove in the Straits of Johore.

There can be no doubt, however, that there is considerable variation in the distribution of the species, not only in different countries but within local limits. The remarks that follow can therefore, only be accepted as generally true for Malaya. They are, none the less, put forward with some degree of confidence and in the belief that the examination of the growing stock and the investigation of its requirements have been carried out more thoroughly in the Federated Malay States than elsewhere. The officer responsible for the statement that reconnaisance lines could not possibly be cut would—were he now alive—find it difficult to believe that there is hardly an acre of mangrove swamp anywhere in the F.M.S., that has not since been traversed on foot and reasonably carefully examined by forest officers, not to mention the detailed topographical work done by the Survey Department and from the air.*

(*b*) THE EFFECTS OF INUNDATION.

In a paper which was prepared for the F.M.S. Forest Conference of 1926, Mr. A. B. S. Boswell discussed the relationship between the frequency of tidal inundation and the distribution of the different species. For this purpose he adopted the following classes:

Class 1. Inundated less than once per month.
„ 2. „ once to 4 times „ „
„ 3. „ 5 to 14 „ „ „
„ 4. „ more than 15 times per month.

This is a more ambitions classification than that attempted by Kurz (28) who was content to divide the Burma swamps into two classes, covered by ordinary high tides and spring tides respectively, and who admitted a good deal of overlap between them.

The summary of tidal data on the opposite page has been compiled from the 1927 official tide table for Port Swettenham. It shows an extreme range of 17.7 feet, between *minus* 1.7 feet on March 5 and *plus* 16.0 feet on October 12. The difference between neap and spring high tides is only 7.5 feet. For the reasons already given in Chapter I (*b*), the neap high-water mark can here be regarded as the extreme limit of terrestrial vegetation, so that this figure of 7.5 feet would appear to include the whole mangrove flora with the exception of some of the semi-inland species of Bruguiera. It is unfortunate that the tidal data for Perak are not sufficiently accurate to enable a comparison, but conditions there seem, on the whole, to be very similar.

A glance at the table will show that Mr. Boswell's classes are untenable, the frequency of inundation being obviously very much greater. This is partially explained by the failure of the Malays

* The whole mangrove area of the west coast of the F.M.S. was surveyed from the air in 1927/28. This form of survey is ideal for mangrove which, on account of its swampy character, imposes a severe strain on the ordinary ground surveyor. The level nature of the country enables the mosaics to be used not only for topographical purposes, but for determining the limits of certain mangrove types. Viewed from a 'plane at an elevation of about 2000 feet, all types are clearly distinguishable, but a little experience is necessary before they can be identified with certainty from the photographs. See illustrations, pages 7, 211 and 212.

HIGH TIDES PORT SWETTENHAM 1927.

Heights of water above Admiralty datum	Number of tides in each class, per month								Total number of high tides	Highest spring tide †	Lowest neap tide	Range
	15′ +	14 +	13′ +	12′ +	11′ +	10′ +	9′ +	8′ +				
JANUARY	—	—	11	22	13	8	4	1	59	13.9′	8.9′	5.0′
*times covered per month	—	—	11	33	46	54	58	59		N		
FEBRUARY	—	5	7	17	10	8	5	2	54	14.3′	8.7′	5.6′
times covered per month	—	5	12	29	39	47	52	54		N		
MARCH	1	7	8	18	9	7	8	2	60	15.0′	8.5′	6.5′
times covered per month	1	8	16	34	43	50	58	60		N + 1		
APRIL	4	6	11	13	8	8	6	2	58	15.3′	8.7′	6.6′
times covered per month	4	10	21	34	42	50	56	58		N + 1		
MAY	4	7	11	15	10	8	4	1	60	15.4′	8.7′	6.7′
times covered per month	4	11	22	37	47	55	59	60		N		
JUNE	—	4	15	17	9	9	4	—	58	14.2′	9.1′	5.1′
times covered per month	—	4	19	36	45	54	58	58		N		
JULY	—	—	22	15	10	9	4	—	60	13.9′	9.1′	4.8′
times covered per month	—	—	22	37	47	56	60	60		F		
AUGUST	—	8	14	15	10	8	5	—	60	14.8′	9.3′	5.5′
times covered per month	—	8	22	37	47	55	60	60		F		
SEPTEMBER	4	6	15	12	8	6	7	—	58	15.6′	9.1′	6.5′
times covered per month	4	10	25	37	45	51	58	58		F + 2		
OCTOBER	1 + 4	8	9	16	9	5	7	1	60	16.0′	8.9′	7.1′
times covered per month	5	13	22	38	47	52	59	60		F + 1		
NOVEMBER	4	6	12	13	10	7	6	—	58	15.8′	9.0′	6.8′
times covered per month	4	10	22	35	45	52	58	58		F		
DECEMBER	1	5	12	16	14	7	4	1	60	15.0′	8.9′	6.1′
times covered per month	1	6	18	34	48	55	59	60		F		
TOTAL	23	62	147	189	120	90	64	10	705			72.3′
times covered per year	23	85	232	421	541	631	695	705				—
Average per month	2	7	20	35	45	52	58	59				6.0′
INUNDATION CLASS	5	4		3		2						

Highest high tide +16.0′ October 12
Lowest low tide — 1.7′ March 5/6
Extreme range 17.7′

† N = New moon; N + 1 = 1 day after new moon.
F = Full moon; F + 2 = 2 days after full moon.

* *i.e.*, the number of times that the tide reaches or exceeds this height during the month.

A DIAGRAM TO ILLUSTRATE
THE TYPICAL, BUT BY NO MEANS INEVITABLE,
DISTRIBUTION OF THE MORE IMPORTANT MANGROVE SPECIES



SECTION ON A-B

REFERENCE

Rhizophora mucronata	*Bruguiera caryophylloides*	*Carapa obovata*	*Ceriops Candolleana*	*Avicennia alba*
Rhizophora conjugata	*Bruguiera eriopetala*	*Carapa moluccensis*	*Sonneratia Griffithii*	*Acrostichum aureum*
Bruguiera parviflora	*Bruguiera gymnorhiza*	*Intsia retusa*	*Avicennia intermedia*	

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(on whose observations the figures are based) to take the night tides into consideration. A more correct estimate would, therefore, be reached by multiplying Mr. Boswell's inundation figures for each class by two, thus obtaining:—

Class 1. Inundated less than twice per month.
„ 2. „ 2 to 9 times „ „
„ 3. „ 10 to 28 „ „ „
„ 4. „ more than 28 times per month.

Even these classes are not easy to reconcile with the table, for a mere difference of a foot in elevation is sufficient almost to treble the frequency of inundation between the 15′ and 14′ levels and the 14′ and 13′ levels; and to add 100 to each of the annual totals between 13′ and 10′. The tide figures are admittedly subject to error and to local variations, and there must also be taken into account the influence of storms and heavy rains, all of which would tend to make the depth of flooding even more irregular than appears in the table. In this connection it might be mentioned that the Port Swettenham tides are exceptionally regular in that the diurnal tides are of approximately equal value, as compared with the superior and inferior high waters that alternate in varying degree at Singapore and on the East Coast; not to mention the extreme case of Penang, where conditions approximating to those on the Solent are said to occur at certain times of the year.

It seems desirable therefore, to avoid any attempt to form inundation classes based on the actual *number* of times or even days that the ground is flooded in each month, and to adopt a classification based rather on the *nature of the tide* that inundates the area. The following scale is suggested as a safe guide, the approximate limits of the classes being shown to enable a rough comparison with the table. These figures are, of course, only applicable (and very approximately at that) to the neighbourhood of Port Swettenham.

Inundation Class	Flooded by	Comparison with table on page 127. Height above Admiralty datum		Number of times flooded p.m.	
		from	to	from	to
1	All high tides			5	62
2	Medium high tides	8	11	4	8
3	Normal high tides	11	13	20	4
4	Spring high tides	13	15	2	20
5	Abnormal or equinoctial tides	11			2

It will be understood that these divisions are entirely arbitrary and that, as far as the forest is concerned, a heavy shower of rain (particularly inland) may reproduce the conditions of inundation in its mechanical, if not its physiological effects. Of the reaction of mangrove to rain little or nothing is known, though there seems some reason to believe that some of the species can thrive in places otherwise unsuited to them provided they can get plentiful supplies of fresh water. A case in point is the occurrence of pure Rhizophoras at the foot of the lighthouse hill at Kuala Selangor where they get the benefit of the surface drainage, probably assisted by springs. A short distance away from the hill these trees are absent or occur sporadically, though the frequency of tidal inundation and other conditions appear to be identical.

In the chart on page 128 an attempt has been made to indicate diagrammatically the distribution of the different species according to the tidal classification suggested above. The details shown in the map are entirely imaginary. It should be noted that the guiding principle in the allotment of a species to any particular inundation class is its ability to regenerate itself, and not merely to exist, under the conditions obtaining within that class. Thus, adult Avicennia is found in dry mangrove and even bordering road drains, in which positions it will produce an abundance of fertile seed. But such trees are survivors of lower inundation classes, and their seeds are unable to establish themselves in the neighbourhood of the parent trees, though they may be carried away by water and succeed in growing in more favourable localities.

The species typical of the different tidal classes are roughly as follow:—

Class 1. **Inundated by all high tides.** It is unlikely that any species can survive complete daily inundation except, perhaps, *Rhizophora mucronata* on the banks of streams, and then only if its head remains above water. On the sea face this inundation class is sterile.

Class 2. **Inundated by medium high tides.** In this class belong the Avicennias (particularly *A. alba* and *A. intermedia*) and *Sonneratia Griffithii* (*perepat*). Bordering the rivers *Rhizophora mucronata* predominates.

Class 3. **Inundated by normal high tides.** In most places this class includes the greater part of the mangrove area. The majority of species will thrive under these conditions, but the Rhizophoras predominate, *R. mucronata* being

found near the streams and, on firm soils, often associated with *Ceriops Candolleana*. *R. conjugata* reaches its optimum development and forms pure stands. *Carapa obovata* occurs where the soil is sandy. *Sonneratia Griffithii* continues to thrive in the upper storey, but cannot reproduce itself. Acrostichum fern grows, but does not thrive. *Bruguiera parviflora* grows well, often in mixture with Rhizophora.

Class 4. **Inundated by spring tides.** Such areas are getting a little too dry for Rhizophoras, which are in danger of supersession by *Bruguiera gymnorhiza* and the regeneration of which is likely to be hindered by *piai* fern. *Tumu* is already plentiful in the undergrowth where there is sufficient light, and common in the upper storey. Where the soil is particularly stiff, *Bruguiera caryophylloides* forms dense pure stands. In the better drained soils, particularly near rivers, *B. parviflora* is common with occasional *B. eriopetala*, the latter species rarely being gregarious. *Carapa obovata* is common in the lighter soils, and *C. moluccensis* is found sporadically towards the limits of the next class. *Lumnitzera coccinea* reaches its largest dimensions in land of this class, but its distribution is guided by factors that are not understood. Prawn heaps, thrown up by *hudang ketak* result in better aeration and the bringing to the surface of shell remains and sand.

Class 5. **Occasionally inundated by exceptional or equinoctial tides.** *Bruguiera gymnorhiza* has here definitely established itself, generally with a dense undergrowth of *piai* fern, which will take charge when the cover is removed. *Rhizophora conjugata* and *Carapa moluccensis* are present as old trees, the former often in the shape known as *bakau tandok*, characterised by minutely fissured beech-grey bark. *Intsia retusa* frequently forms good clean stems which would, no doubt, find favour with timber cutters if transport conditions were more favourable. Epiphytic figs and climbers are common, and *Oncosperma filamentosa* sometimes forms almost pure stands above the reach of the highest tides. It is in areas of this class that Nipah plantations are most likely to be successful, particularly where the soil is stiff.

Summary.

In the following alphabetical list, the optimum requirements of the different species with regard to soil and frequency of inundation are summarised. It must be clearly understood that most species can exist within much wider extremes than those attributed to them here:

No.	Name.	Inundation classes.	Soil and position.
1	*Acanthus ebracteatus.*	4.5.	Loam or clay on river banks and clearings.
2	,, *ilicifolius.*		
3	*Acrostichum aureum.*	3.4.5.	Almost everywhere if light.
4	*Aegiceras majus.*	3.4.	Loam on river banks not far from sea.
5	*Avicennia alba.*	2.	Deep mud within the influence of rivers.
6	,, *intermedia.*	2.3.	Firm mud on sea face.
* 7	,, *lanata.*	2.3.	Sandy mud not far from sea; Singapore and E. Coast.
8	,, *officinalis.*	3.4.	Stiff soil on river banks.
9	*Brownlowia lanceolata.*	4.	River banks and open spaces.
* 10	,, *Riedelii.*	5.	Sandy mud on river banks.
11	*Bruguiera caryophylloides.*	4.	New clay deposits near sea face.
12	,, *eriopetala.*	3.4.	Loam; often associated with 11 & 14. Usually sporadic.
13	,, *gymnorhiza.*	3.4.5.	Loam or sandy mud. Gregarious in dryer areas.
14	,, *parviflora.*	3.4.	Will grow almost anywhere in mangrove if well drained.
15	*Carapa moluccensis.*	4.5.	Loam near tidal limit.
16	,, *obovata.*	3.4.5.	Sandy mud and river banks.
17	*Cerbera lactaria.*	4.5.	River banks near tidal limit.
18	,, *Odollam.*	5.	Sandy sea beaches.
19	*Ceriops Candolleana.*	3.4.	Loam near river mouths.
* 20	*Cycas Rumphii.*	5.	Sea beaches and inland.
21	*Daemonorops leptopus.*	5.	River banks above mangrove.
22	*Derris uliginosa.*	4.5.	Loam on river banks.
23	*Excoecaria Agallocha.*	4.5.	Clay; often behind 11.

* These species are peculiar to the east-coast.

No.	Name.	Inundation classes.	Soil and position.
24	*Heritiera littoralis.*	5.	Sandy loam; river banks and inland edge of mangrove.
25	*Hibiscus tiliaceus.*	5.	Loam; river banks inland.
26	*Intsia retusa.*	5.	Loam above tidal limit.
27	*Kandelia Rheedii.*	4.	River banks. Not seen in Perak. Sporadic elsewhere.
28	*Lumnitzera coccinea.*	4.5.	Loam. Inland edge of mangrove. Sometimes near sea.
29	,, *racemosa.*	4.5.	Clay. Sometimes behind 11.
30	*Nipa fruticans.*	3.4.5.	River banks within the influence of fresh water.
31	*Oncosperma filamentosa.*	5.	Clay or loam above tidal limit. Equally happy inland.
32	*Pluchea indica.*	5.	Clearings behind mangrove.
* 33	*Podocarpus polystachyus.*	5.	Sandy mud behind mangrove or on high river banks.
34	*Rhizophora conjugata.*	3.4.	Loamy mud everywhere, but not on sea face.
35	,, *mucronata.*	2.3.	Deep mud within the influence of rivers. Not on sea face.
36	*Scyphiphora hydrophyllacea.*	3.4.	Loam or sandy mud on river banks and open spaces.
37	*Sonneratia alba (Gedabu).*	3.4.	Loam; often some distance from river banks.
38	,, *acida (Berembang).*	4.5.	Loam; within the influence of river water.
39	,, *Griffithii (Perepat).*	2.3.	Rich mud on sea-face or river banks; often with 35.
40	*Thespesia populnea.*	5.	Sandy beaches.

(c) The Types of Mangrove Forest.

A number of definite types of tree growth are distinguishable in the littoral forests, among the chief influencing factors besides the frequency of inundation being drainage, the character of the soil, the age of the swamp, the erosive or accresive action of the sea, and the artificial conditions brought about by exploitation. They are not, of course, always clearly defined, though the boundaries are often surprisingly distinct in spite of the superficial similarity of conditions and the absence of marked topographical features.

* These species are peculiar to the east-coast.

For the purposes of this chapter the forests have been divided into five main classes, viz:

(*a*) The *Api-api-Perepat* type, which prepares the ground for

(*b*) The *Berus* type (on the sea-face only).

(*c*) The *Lenggadai* type which, although usually associated with, is held by some to precede, and by others to succeed

(*d*) the *Bakau* type. Both this and the former merge gradually into

(*e*) the *Tumu* type, which passes over imperceptibly into inland forest.

This arrangement follows, very broadly, the sequence in which the types establish themselves, *api-api* (*Avicennia alba* and *A. intermedia*) being the pioneer species, whilst *tumu* (*Bruguiera gymnorhiza*) is typical of the transition from littoral to inland forest.

(*i*) The Api-api-Perepat Type.

The pioneer efforts of certain of the Avicennias and Sonneratias have already been referred to in the general description of the formation of swamps (Chapter I) and the peculiarities of the individual species are discussed in Chapter II.

In the class of forest now under consideration, two sub-types are distinguishable, viz., the shoal type formed out at sea by deposits of sand and suspended matter and not connected with the mainland or established island forests; and the accretion type, where the action of the sea is assisted by the silt brought down by the rivers or washed down by the rains from the neighbouring higher lands and deposited on the seaward edge of existing forests.

In both types the Avicennias (*api-api*) are normally the first to establish themselves, but where the mud is deep and rich in organic matter, *perepat* (*Sonneratia Griffithii*) may get there first. Should the deposits be of a stiff clayey nature the Avicennias are usually followed by *berus* (*Bruguiera caryophylloides*). *Perepat*, on the other hand appears to be normally succeeded by *bakau kurap* (*Rhizophora mucronata*) and, speaking generally, to point to much more favourable soil conditions than those associated with *berus*.

Excellent examples of shoal formation in its different stages are to be seen in the neighbourhood of Port Swettenham, where the action of currents and tides is constantly depositing large

quantities of sand and silt far out to sea in the form of a belt, which is continuous at low tide, but broken up at high tide into a series of islands in varying stages of development. They are all completely submerged at average high water, but it is only on those that remain uncovered during the neap tides that vegetation has been able to establish itself. Here it is very noticeable that where *Avicennia intermedia* forms the sole crop the ground is comparatively firm and easy to walk on; but where either Sonneratia or *Avicennia alba* is prevalent the mud is blacker and softer and walking is much more difficult.

Extensive mainland accretion forests occur almost anywhere along the west coast where erosion is not in progress. Typical examples can be seen at Kuala Selangor and all along the coast of Province Wellesley and Perak. Here the process is different from the island formations, the deposits containing a higher proportion of clay, and *perepat* being absent except within the influence of the rivers. The crop on the sea face consists of almost pure *api-api, Avicennia intermedia* being the commonest species. This gradually merges into a pure crop of *berus (Bruguiera caryophylloides)* which continues up to the limits of alienation for coconuts and similar crops. Unsuccessful attempts were made a few years ago, to assist the *berus* by ringing and painting the older *api-api* with Atlas preservative, the idea being that this treatment would enable the former species to come in more rapidly. The actual result was to stimulate the growth of the *api-api* seedlings which, had they been left to themselves, would not have survived the shade of the parent trees and would certainly have failed to hold their own against the more shade-bearing *berus*. A still earlier attempt to establish Rhizophora plantations was defeated by the unsuitability of the soil and the attentions of monkeys.

In the Banjar Reserve, in the neighbourhood of Kuala Selangor the deep, soft, almost impassable mud on the seaface is occupied by *Avicennia alba*, whilst the firmer soil supports *A. intermedia*, at first pure, but gradually merging into *berus*. The boundary between the two Avicennias is, in places, clearly marked by a belt of dead and dying trees, marking the limits of the influence of the rivers, beyond which *A. alba* does not seem able to thrive. The abruptness of the transition demonstrates that the two species have very different requirements of soil and situation, and tends to disprove the close affinity formerly attributed not only to these two forms of Avicennia but also to the other two species of the same genus which are discussed and described in Chapters II and III.

(*ii*) The Berus Type.

The outstanding characteristic of the *berus* type of forest is the stiff clay soil on which, except after high tides, it is possible to walk with comparative ease, in spite of the many projecting knee-like pneumatophores.

Typical *berus* areas are above the reach of ordinary tides and are only flooded during the day or two preceding and following spring tides. The surface is, therefore, normally free from water, and is covered with a few inches of raw humus, often of a pinkish tinge as opposed to the darker and thicker organic layer that is found in the older *bakau* areas. The blue clay subsoil is near the surface, which usually carries a thin layer of silt and, in the long periods between inundation, and in the absence of rain, is often traversed by shallow cracks. Streams are conspicuous by their absence, large areas being frequently entirely dependent on surface drainage partly seawards, but chiefly towards the larger streams further inland.

As indicated in the next preceding section, *berus* (*Bruguiera caryophylloides*) is associated primarily with the accretion type of *api-api* forest, behind which it often forms extensive pure stands. It is not typical of the river forests, from which it is usually entirely absent. Except for one or two small stretches where Avicennia merges direct into Rhizophora forest, there is, on the west coast, a practically continuous belt of *berus* behind the *api-api*. This belt may constitute practically the whole exploitable mangrove area, as at Banjar, near Kuala Selangor, and Kuala Kurau in Perak; or it may occupy extensive areas to the seaward side of the *bakau* forests, as at Trong and Pasir Hitam Islands in the Matang reserves, Perak; or it may degenerate into a comparatively insignificant strip in mixture with *lenggadai* (*Bruguiera parviflora*) and *tengar* (*Ceriops Candolleana*). On the east coast, where the swamps are of the riverine type, *berus* is far less common and in many places even unknown.

As there can be little doubt that, generally speaking, the mangrove swamps are extending seawards, and as the normal progress in this direction appears to be accompanied by the formation of a more or less continuous outer belt of *berus* occupying land that is only inundated by spring tides, how comes it that the later formations behind this belt of *Bruguiera caryophylloides* occupy soils in a lower inundation class? If *berus* habitually precedes the Rhizophoras and other species yet to be described, its natural habitat would appear to be a lower rather than a higher level.



47. *Avicennia intermedia* with natural regeneration of *Bruguiera caryophylloides* (BERUS).



48. Pure BERUS forest (*Bruguiera caryophylloides*); self-thinned

That this is most definitely not the case is so easily proved that it may be accepted without argument. Can its position as a pioneer species be equally easily established, or must it be regarded as an unorthodox form that may or may not follow the normal sequence and which demands certain conditions of soil and drainage that do not necessarily arise?

One fact that is quite definite is its occurrence behind Avicennia on the sea face. The habitat of few other species can be described with such certainty and within such narrow limits. With almost equal certainty it may be allotted to a type of soil (blue clay with a few inches of semi-decomposed organic matter) that is younger than that occupied by the Rhizophoras. Both these factors favour its position as No. 2 in the scale. But *berus* very definitely belongs to an inundation level in which the Rhizophoras, although they still occur, have passed their optimum development and are beginning to reach that stage when their further regeneration is doubtful. This would appear to indicate an inferior position in the scale. Can these apparently contradictory pieces of evidence be reconciled?

As regards the comparatively high level of the *berus* banks, a satisfactory explanation can be found in the pounding action of the waves, which would tend to pile up and maintain deposits on the sea-face. These deposits consist of practically pure clay, which is virtually incompressible, so that it is obvious that the development of roots must be followed by the raising of the surface, quite independently of any precipitations from above. If an eroded area or a canal bank running through *berus* forest be examined it will be noticed that this species possesses a strongly developed root system with an abundance of pneumatophores springing from fleshy and extremely porous laterals. It must also be remembered that Avicennia, the immediate precursor and (in the early stages) associate of *Bruguiera caryophylloides* has even more extravagantly developed surface roots and pneumatophores (see illustration page 3). Taking these facts into consideration, and bearing in mind the rapidity with which the transition from Avicennia to Bruguiera is effected, and the extraordinarily dense stocking and the resultant self-thinning that are typical of the latter species, it is not difficult to account for a rise of several inches within a single generation and the formation of a thick layer of raw humus within a very short time. It is equally easy to imagine a corresponding fall in the event of any accident to the growing stock. As is shown by the table on page 127, a rise or fall of a single foot may have a profound effect on the frequency of inundation, particularly in the higher classes.

But why, having established itself above the reach of anything but the highest tides, should *berus* not continue indefinitely in possession, seeing that it is practically immune to invasion from water-borne species? It is clear that these latter can only find their way into the undergrowth if the level of the soil subsides sufficiently to allow inundation by ordinary high tides. That they do so is an established fact. How then is this phenomenon brought about?

A clue to the problem appears to have been provided by the behaviour of *berus* in the neighbourhood of Kuala Kurau, where the erection of a bund to keep out the sea water from a coconut estate has interfered with the surface drainage towards the landward side, with the result that large patches of forest have been killed. The almost entire absence of aeration in the dense clay habitually occupied by *berus* makes the tree more than usually dependent on its pneumatophores for an adequate supply of oxygen, and particularly susceptible to prolonged submersion. Suffocation on a much more extensive scale has occurred in the centre of Trong Island in the Matang forest reserve, Perak, where the progressive dying off of *berus* forest over an area that had grown to over 100 acres has recently been checked by the cutting of an extraction canal, which has allowed the accumulated surface water to drain away towards the landward side. Here, however, there is no very obvious explanation for the cessation of natural drainage towards the land, though an attractive theory is that it has been caused by a local crater-like subsidence in the semi-fluid clay subsoil following erosion by the sea, which is here proceeding very rapidly. There are evidences of similar phenomena in adjoining areas, and of fluctuating erosion and accretion within human memory.

But whatever the cause, the evidence in both cases points to a gradual but definite drainage *away* from the sea. This appears to supply a satisfactory explanation of the gradual subsidence of the *berus* banks, for the tendency would be for the receding tidal and rain water to carry off the surface silt and for this to be borne by the rivers to the sea and re-deposited on the sea-face. The result would be a gradual seaward movement of the *berus* bank at the expense of the landward side, the level of which would be ultimately reduced to that of the adjoining *bakau* areas. The tendency would further be for the silt rather than the raw humus to be removed by the slowly receding waters, the latter being left to enrich the soil and render it more suitable for the Rhizophoras, which reach their optimum development where there is plenty of organic matter, better drainage, and greater aeration than is ever found in typical *berus* areas.

Whether or not the process is as described above, there is good reason to believe that *Bruguiera caryophylloides* is a legitimate precursor of the Rhizophoras in most situations where accretion is proceeding on the sea-face. The elevated levels that it occupies should not, therefore, be regarded as being on the verge of supercession by inland forest, and for that reason inferior. Parts of them may of course, deteriorate into "*hutan darat*"* without passing through the Rhizophora stage but the greater portion is more likely to yield to the more valuable and longer lived Rhizophoras, and thus replace the areas of decreasing productivity that are described later.

The tree is a prolific seed-bearer and produces large crops of comparatively small fruit which are readily dispersed by rain water as well as by occasional high tides. Healthy *berus* forests are, therefore, but little troubled by *piai* and other weeds and can be relied upon to regenerate themselves even after clear felling without the necessity for special precautions.

Where *piai* fern is found under Berus it is generally in the shape of the large fronded "*raya*" form, which seems to be associated with an excess of fresh water. This, and the fact that *piai* is the only surviving plant in the drowned area at Pasir Hitam, suggests that its presence there is connected with previous disturbances of a similar character.

The best *berus* forests are to be seen in the Banjar reserve in the neighbourhood of Kuala Selangor, and in the Trong Island section of the Matang reserve in Perak.

(*iii*) The Lenggadai Type.

Lenggadai (Bruguiera parviflora) is not infrequently found associated with *berus*, but more often with *bakau*. It is the smallest of the commercial mangroves. Though it is quick to establish itself, such statistics as are available indicate that it is a comparatively slow grower and has the shortest life, particularly when it occurs in pure stands, as it frequently does in the wetter areas. Essentially an opportunist species, it often establishes itself in soils formerly occupied by *bakau* (*Rhizophora spp.*) which, on account of failure of the seed crop or unfavourable tides have failed to regenerate themselves after felling. It is particularly common on river banks where excessive pole cutting has been indulged in by fishermen. The seed is small and capable, therefore, of distribution by rain water without the agency of high tides, though probably not to the same extent as *B. caryophylloides*.

* Inland forest.

It would appear safest to look upon *lenggadai* as a parallel type to *bakau*, capable, by virtue of its opportunist character, of occupying either a superior or an inferior position, but liable to be replaced by the more shade-bearing and longer-lived Rhizophoras where conditions are favourable to the dispersal of their seed. The optimum conditions for its natural occurrence appear to be the same as for *bakau* except that it prefers, if anything, a rather stiffer soil with frequent inundation and good drainage.

Because of the slight inferiority of its firewood *lenggadai* is frequently regarded as a weed or as an undesirable species. This may be a true description of it where it forms pure crops, as it appears to be unable to stand the full rotation of 40 years, and it would be difficult under existing conditions to devise a working scheme which would permit of a shortening of this period to suit any one species. But, as a nurse to the Rhizophoras, *lenggadai* is very much to be encouraged, whether in the form of seedlings, poles, or mature timber. In mixture with *bakau* it seems able to go the full rotation, the resulting yields being not only heavy, but the individual trees being unusually tall, free from knots, and of a size, shape and fissibility that are appreciated by the firewood cutters. Moreover, such areas present an easier problem for regeneration than do pure stands though, as *lenggadai* is more prolific than *bakau*, successive crops are likely, at first, to show an excessive proportion of the former unless assistance is given.

There is some difference of opinion as to the real position that *lenggadai* occupies in the normal sequence. Its frequent preponderance in areas that were formerly occupied by *bakau* suggests that it succeeds that species, but it is equally reasonable to regard such cases as set-backs brought about by the abnormal consequences of clear felling, and to assume that the *lenggadai* will be replaced by *bakau* in due course. That this species plays a similar role in Burma is evident from the following extract from the inspection notes of Mr. C. G. Rogers (44). Speaking of Tenasserim forests he says:

> "There can be no doubt that this worthless species is spreading fast and is occupying ground formerly occupied by valuable mangroves. .....If nothing is done to help the natural regeneration of the valuable species of Rhizophoras, the proportion of these species in the littoral forests must rapidly decrease. Fortunately, the regeneration of both species of Rhizophora is very good, and all that needs to be done to ensure their regeneration is to cut back the seedlings of *knit* (*B. parviflora*), where they occupy the ground, in order to allow seedlings of Rhizophoras to establish themselves. Where seed-bearers of the Rhizophoras are wanting, it may be necessary to collect germinating seeds from trees near by, and stick them in the mud."

It should be mentioned that the writer of these words was considering the tree from the point of view of its potentialities as a producer of commercial tannin, in which respect the adjective "worthless" is not unjustified.



49. Pure LENGGADAI forest (*Bruguiera parviflora*).



50. Typical BAKAU forest (*Rhizophora conjugata* and *R. mucronata*).

To describe an area, therefore, as "good for nothing but *lenggadai*," displays ignorance of the close connection that exists between that species and the Rhizophoras. Areas there doubtless are on which *lenggadai* has succeeded in establishing itself and maintaining a precarious existence where natural regeneration of the larger seeded species is no longer possible, but these are merely abnormalities, usually brought about by outside interference.

(*iv*) **The Bakau Type.**

The conditions under which the Rhizophoras form the bulk of the growing stock may be regarded as the optimum stage of development of the mangrove swamps. These conditions are, briefly, inundation by ordinary high tides, aeration and enrichment of the soil to a depth of some feet by pioneer species, and an abundance of small streams to assist in the distribution of the seed. The soil in a typical *bakau* area is always of a dark colour, rich in humus, and with a slight, but not at all obvious, admixture of fine sand, particularly in the higher stretches where there is a sandy subsoil, the distribution and aeration of which is assisted by *hudang ketak*.

The *bakau* type comprises the greater proportion of the whole mangrove area, probably forming at least 75% of the growing stock in inundation class 3 and a considerable proportion of classes 2 and 4, provided that the soil is not too new. In stiff clay, such as that favoured by *berus*, the Rhizophoras will not thrive, but they are quite at home in equally dry soils if they are sufficiently aerated, and they will continue to exist as far inland as any other of the Rhizophoraceae with the possible exception of *Bruguiera gymnorhiza*.

It is not easy to form an estimate of the comparative frequency of the two species, but it seems reasonably certain that *R. conjugata* covers considerably larger areas, though *R. mucronata* is the more conspicuous on account of its proximity to streams and creeks. Generally speaking, the latter occupies the wetter spots, its absence from the less deeply inundated areas being due to the size and unwieldiness of its seeds rather than to unsuitability of soil or lack of water.

The *bakau* forests are unmistakable on account of their tangled stilt roots, which seem to develop in inverse proportion to the stems, trees growing in sandy, shallow, or inferior soils, or in very deeply flooded areas, being provided with the most fantastic roots, whilst those growing under optimum conditions are not at all conspicuous. Local experience does not bear out Schimper's observation on p. 35 of (47) that the roots are less strongly developed in the drier situations.

As already stated in the section dealing with that species, *lenggadai* (*B. parviflora*) is a close and desirable associate of *bakau*. A less useful species is *nyireh bunga* (*Carapa obovata*), which often occurs in excessive proportions, particularly where the soil is shallow and sandy. Its shallow and extensive root system effectively discourages the regeneration of *bakau* in its immediate vicinity, and its powers of coppicing and of surviving even the attentions of the bark collectors (who frequently strip most of the bark from the bole) make it a difficult pest to eradicate. It is doubtful whether the special *nyireh* passes used in Singapore and Johore have lowered the proportion of that species in the *bakau* areas for which they were issued.

Old *bakau* forests usually show signs of *piai* in the undergrowth, particularly where a sandy subsoil has enabled burrowing prawns (*hudang ketak*) to construct mounds on which the fern can establish itself out of reach of any but the highest tides. These are always a source of danger, for seed dispersal is obviously restricted in such places, and unless regeneration is accomplished before the removal of the parent trees it is likely to be difficult to establish after the growth of the *piai* has been stimulated by the increased light. This question is dealt with more fully in the chapter on silvicultural systems. *Tumu* and its ill effects on the *bakau* forests are best discussed in the section dealing with that type.

(*v*) The Tumu Type.

Bruguiera gymnorhiza marks the final stage in the development of the littoral forests and the beginning of the transition to ordinary inland forms. *Tumu* is the largest and probably the longest lived of the Rhizophoraceae, and its occurrence in the early stages is markedly sporadic. It can stand any amount of shade, and its seeds are short and comparatively easily dispersed, so that it is frequently able to establish itself in pure *bakau* stands when the shade is too dense for the *bakau* seedlings to develop. Its growth in the early stages tends to be spreading and distorted, so that a small number of *tumu* in the undergrowth by virtue of their shade bearing propensities, can eliminate a far greater number of seedlings of other species.

Though fertile seed is regularly produced in abundance from a very early age, regeneration beneath the parent trees is insignificant. *Tumu* might be described as a cuckoo species, leaving the nursing of its progeny to be carried out by others. Having attained its object, it exhibits a similar intolerance towards its immediate neighbours and often effectively discourages further regeneration



51. RHIZOPHORAS at average high tide. The light stems are *R. conjugata*; the rough dark ones are *R. mucronata*. Same trees in frontispiece.



52. Pure TUMU forest (*Bruguiera gymnorhiza*). An unusually fine stand.

of even its own species. Where *tumu* has succeeded in establishing itself in wet mangrove areas it is not uncommon to find, after felling, that the ground formerly occupied by this tree remains bare for a considerable time, whilst immediately adjoining areas originally occupied by other species have regenerated themselves reasonably fully. That this should be the case in wet coupes ideally situated for unhampered seed dispersal by water suggests that *tumu*, being at the end of the mangrove sequence, imparts some peculiar quality to the soil that is unfavourable to its own progeny and to the mangrove species that normally precede it, but that would not be distasteful to the inland forms that would follow it were the physical conditions more favourable. Contributory causes are to be sought in the dense shade cast by the tree in its earlier stages, and the consequent absence of advance growth; in the absence of stilt roots to provide shelter and anchorage for seedlings and to prevent excessive movements of drifting slash; in the closely packed pneumatophores, which prevent a large proportion of the seeds from penetrating the mud; and in the ravages of crabs, which are particularly severe in such places, and which add to the difficulties of artificial regeneration. See fig. 56, p. 155.

Dry areas on which *tumu* forms the main crop have concluded their period of usefulness for the time being. Natural regeneration is scanty, the bulk of the undergrowth consisting of *piai* fern, which takes charge as soon as the cover is removed and which effectively prevents planting, except at enormous and quite uneconomical expense. The level of the ground has been raised by successive humus deposits, and by the activities of prawns, until it is permanently above the reach of even the highest tides, so there is no longer anything to hinder the supercession of mangrove forms by inland types, the advance of which is heralded by *Carapa moluccensis* (*nyireh batu*), *Intsia retusa* (*ipil*), *Ficus retusa* (*jejawi*), *Pandanus spp.* (*pandan* or *mengkuang*), *Daemonorops leptopus* (*rotan bakau*), and many others. The process is usually hastened by the alienation of the border lands for agriculture.

It must not be thought from the above generalisations that all mangrove inevitably passes through the entire sequence of development, or that all types are represented even in extensive swamps. Nor need it be assumed that the appearance of *tumu* necessarily denotes deterioration, or even that accretion is invariably associated with *api-api*. Over-aged *berus* does not always die with dramatic suddenness, and *nyireh* may be found growing in company with species other than *bakau*. But it is believed that the species perform within very broad limits the functions ascribed to them, and that attention to the normal development of the types of forest should simplify some of the silvicultural problems with which the forester is confronted.

(*d*) Dangers to which the Crop is exposed.

Unlike most gregarious trees, the mangrove species do not suffer from epidemics of any description, unless the wholesale dying off of *berus* already referred to can be included in this category.

Fungi. Fungoid pests are insignificant. The branches of *Avicennia* (particularly *A. alba*) and *Sonneratia Griffithii* are frequently covered with a black rust which makes them look as though they had been smoked over a sooty flame, but which seems to be quite harmless. The extruded radicles of *Rhizophora mucronata* occasionally develop a peculiar disease characterised by a brown discolouration, and dying of the tissues, starting in the middle and extending upwards and downwards until the whole length may be affected. Needless to say, such seeds will not grow. When broken, they exude a very characteristic peach-like odour. The disease has only recently come under observation: the causative fungus is probably a species of *Cryptospora*. Fruiting bodies of *Fomes* and other conspicuous species are often seen on dead and dying trees, but they have no primary significance.

Insects. Harmful insects are noticeable by their absence. Bark and wood borers are common enough but their attacks are purely secondary. The same may be said of ants and termites. The larvae of what is believed to be a cerambycid beetle have been found in burrows immediately beneath the bark of over-mature trees of *Bruguiera parviflora* and are probably instrumental in hastening their demise. Avicennia is occasionally partially defoliated and even killed by the attacks of lepidopterous larvae, though nowhere has this been reported over large areas. Nipa leaves are often badly damaged by the black and green caterpillars of a moth (*Parasa letida*), which cause a good deal of trouble in plantations and which require to be collected and destroyed.

Crabs. The most serious enemies to mangrove are crabs, particularly *Sesarma taeniolata*. It is doubtful whether these pests do much damage under natural conditions, but they certainly can, and do, cause great trouble in plantations. *Rhizophora conjugata* is particularly susceptible to their attack, which takes the form of devouring the bark of young seedlings until they are completely girdled or even bitten right through. Zoologists have scoffed at the idea of crabs adopting a vegetarian diet, but whether this particular kind eats the bark or removes it for some other purpose, the effect on the plant remains the same. In some places, particularly in Selangor, it has been found impossible to establish mangrove seedlings in certain areas unless they are protected by

bamboo tubes about 12 inches long, a projecting spike being left on one side to enable the tube to be stuck firmly into the mud without interfering unduly with the development of the side roots. The bottom of the tube must, however, be inserted an inch below the surface. Needless to say, such plantings are very expensive and quite impracticable on a large scale. *Nipa* seedlings in plantations are usually protected by miniature fences of split bamboo and wire.

Attempts to make the seeds distasteful by treating them with red lead have not proved successful. Foxworthy (16) records that, in the Philippines, they are adequately protected by a preliminary drying out under shade, but, though this method has been tried in this country, the only deterrent effect that it has had has been on the germination of the seeds. The crabs eat them as readily as they do the others. A Forester in the Dindings claims to have discouraged them by scattering the chopped "cabbage" of the poisonous *ibul* palm (*Orania macrocladus*), but this requires confirmation elsewhere and is, in any case, not likely to be practicable over extensive areas.* It is claimed that late season's plantings are more likely to be successful, partly because the weather is usually cooler, but chiefly owing to the superior vigour of the later seed crop.

Crab attacks vary greatly in intensity and duration. It is not possible to state which particular conditions are most suitable to them, because it is not always easy to distinguish between cause and effect. Plantations are largely made in places where natural regeneration has already failed on account of crabs. It is, therefore, hardly reasonable to expect artificial regeneration to be more successful; nor is it quite fair to say that crab attack is a result of planting. The mere presence of *Sesarma taeniolata* is no proof that regeneration will not be a success, for there are plenty of places where the beast swarms, but where there is no visible sign of damage. It is claimed in Selangor that the bamboo crab protectors can safely be removed from the seedlings after a month or six weeks; whilst it has been observed in Perak (where, be it noted, crab attack is generally less severe than in Selangor) that damage is not confined to the youngest seedlings and may extend to rooted and even branched plants.

It is probably correct to say that, generally speaking, crab attack is relatively insignificant under shade, and that there is something about clear felling which somehow disturbs the balance of nature in a way that sometimes induces the crabs to turn their attention to the seedlings. Further than this it would not be safe to go. This would appear to establish a case for some form of

* The toxic qualities of this substance have recently been disproved, as far as crabs are concerned, by feeding it to a number of these animals confined in a cage under otherwise natural conditions. No deleterious effects were apparent.

shelter-wood treatment. That crab damage is not entirely governed by light and shade, or limited to certain conditions of moisture, is proved, however, by its occurrence amongst *piai* fern in dry soils, as well as in the open in the wettest part of the swamp. Further notes on planting will be found in Chapter V (*vii*).

Other Animals. Monkeys are occasionally mischievous in plantations, where they pull up the seedlings and throw them about. Where planting in bamboo tubes is to be undertaken, it is recommended that these be put out a week or so in advance of the seedlings so as to enable the monkeys to become accustomed to the novelty of them. After they have pulled up a few they will get tired of the game and cause no more trouble.

No other animal has been reported as doing any appreciable damage in the mangrove.

Vegetable Pests. The mangrove swamps are not troubled by parastic growths. Where they are verging on the inland type, epiphytes are not uncommon, and climbers may do a certain amount of damage. It is noteworthy that stems that have been constricted by spiral climbers carry the resultant impression permanently, even though they may have been freed at a comparatively early age, and that they are particularly difficult to split.

Acrostichum aureum, or *piai* fern, can be a difficult pest to deal with, though with it, as with crab attacks, it is not entirely safe to generalise. It occurs in two forms known as *piai lasa* and *piai raya*, the former being comparatively small and tufted, whilst the latter may reach a height of 12 feet or more, and form a continuous thicket through which progress is almost impossible. Though the differences between the two are unmistakable, they are said to have no botanical significance. It has been suggested that the larger form develops in places subjected to occasional inundation by fresh water, *e.g.*, in the *nipah* belt. Areas that have become covered with *piai raya* may generally be considered useless for further firewood production. It is, at any rate, uneconomical to attempt to plant them up or to clear them, though the possibility of establishing plantations under such conditions was demonstrated in the Dindings some years ago, but without regard to cost.



53. *Acrostichum aureum*. The larger form known as PIAI RAYA.



54. *Acrostichum aureum.* The smaller form known as PIAI LASA.



55. Felling slash. An impediment to natural regeneration.



56. A TUMU blank. Areas in wet mangrove formerly occupied by Tumu (*Bruguiera gymnorhiza*) often remain unregenerated in spite of frequent inundation.



57. BAKAU MINYAK (*Rhizophora conjugata*), showing the limited area covered by natural regeneration in the absence of water dispersal.

The smaller form is commonest where there are plenty of prawn heaps on which it can grow above the reach of the medium high tides. It is not, however, killed by frequent inundation by salt water, and it is often found in wet areas, even under comparatively dense shade. In such places its growth is sparse and, provided that steps are taken to secure natural regeneration before the seed-bearers are removed, its presence is desirable rather than the reverse. The danger lies in its sudden exposure to light before regeneration has been accomplished, for its growth is thereby stimulated to an extent that makes it impossible for drifting seed to penetrate it. The instructions to forest guards enumerated on page 181 are governed primarily by the exigencies of this weed, and their observance should suffice to keep it in check. The planting up of unregenerated *lasa* areas should not be delayed, though care should be taken to ascertain beforehand that the fern does not screen an adequate crop of young seedlings. If these latter are present they should need no assistance, the fern acting as a nurse until the trees are old enough to check its further development.

Flood Damage. The disastrous floods on the East Coast at the beginning of 1927 did considerable damage to the mangrove growing in the rivers, much of which was washed away, or killed by excessive deposits of silt and sand. Large numbers of trees died as a result of prolonged inundation by water which was practically fresh, one of the worst sufferers in this respect being *tumu* (*Bruguiera gymnorhiza*). It cannot be said whether this was a simple case of drowning, or whether the fact that the water was fresh had any bearing on the cause of death; but the absence of stilt roots, the naturally dry habitat, and the fact that this tree is normally accustomed to a greater proportion of fresh water than any of the other species, all point towards the former. It was noticeable that *nipah* scarcely suffered from either immersion or silt. Foxworthy (16) records that in the Manila Bay Rhizophora plantations, seedlings are sometimes killed by an excess of fresh water. Most, if not all, of the mangrove species are, however, able to germinate (*i.e.*, to produce leaves and roots) if planted in wet soils entirely destitute of salt, and to exist for some months in fresh water swamp.* When they begin to show signs of flagging they can be revived by the addition of a small quantity of salt. It seems probable that their powers of resistance are dependent rather on

* Haberlandt (22) records that specimens of *Sonneratia acida* and *Bruguiera conjugata* were growing in the botanic gardens, Buitenzorg, at the time of his visit in 1909.

the reserves of nutriment in the fleshy radicles than to any special adaptability to environment, and that the established saplings are, therefore, less resistant than the seedlings.

Slash. The disposal of slash presents a problem that has yet to be solved. Insistence on more thorough exploitation has accomplished a good deal in this direction, and improvement in silvicultural methods, by increasing the proportion of utilisable wood, will accomplish still more. Large accumulations of brush-wood present an impenetrable obstacle to efficient regeneration from outside, though they may afford a certain amount of protection to seedlings already on the ground.

Decay is very slow. Planting amongst the slash is frequently impossible and, before it has decayed sufficiently for anything to be done, *piai* fern may have established itself. Burning *in situ* cannot easily be brought about, because the leaves are scanty, contain a lot of water, and have fallen long before the not particularly inflammable branches are dry enough to burn. In the wetter areas it is doubtful whether they are ever dry enough. Moreover, burning would involve the destruction of what little regeneration there is on the ground already, and leave the area more impoverished than ever. If the slash would float, it would not be difficult to dispose of at high tide but, as it will not, it must be left to rot where it lies. All that can be done is to treat it like *piai* fern; as an inevitable form of undergrowth that can only be kept within reasonable limits by the vigilance of the supervising guards, and which need do no great harm if natural regeneration is secured in advance.

Chapter V.

MANAGEMENT.

(*a*) Objects of Management.

Working schemes in the mangrove have always had as their main object the production of the greatest volume of firewood by the simplest and cheapest possible methods. The requirements of fishermen in the way of stakes for their traps, building materials for their houses, and tannin for their nets, have not been overlooked; but, speaking generally, they may be said to have been secondary considerations, regarded rather as necessary but somewhat vexatious complications in an otherwise simple division of the total available area into approximately equal annual coupes. Timber production, apart from scaffold poles and fishing stakes, has never been considered as a legitimate function of the mangrove swamps, chiefly because there has always been an abundance of superior material available at a short distance further inland.

Good timbers occur sporadically in the shape of *dungun*, *teruntum*, and *nyireh batu*; but all of these grow only in the drier areas, and none of them are anywhere found in sufficient abundance to acquire anything more than a very local commercial significance. Their merits are discussed in Chapter VI.

(*b*) Past Working Schemes and their Results.

The first attempt at a definite working scheme was made in Perak in 1904, following the reservation of the island swamps in 1903. Nothing was known of the composition of the forests or the rate of growth or regenerative ability of the species comprising them, so an entirely arbitrary rotation of 20 years was adopted at the suggestion of Mr. H. C. Hill, (afterwards Inspector General of Forests, India) who visited and reported on the forests of this country in 1900.

The reserved area was divided into five so-called working circles, and of each of these one twentieth was selected for cutting each year. There were thus five coupes, varying in size from 365 to 1130 acres, the largest being reserved for the contractor supplying the railway department, whilst the rest were put up to tender and sold to the highest bidder. It can readily be imagined that this scheme, which allowed an area exceeding the present total annual coupe to be cut within an area of a little more than one half of the size of the present felling cycle—and cut, moreover, at a time when

the demand for fuel was very much smaller than it is now—was not calculated to regulate cutting any better than the permit system which preceded it. It is true that work was more localised and that it could, therefore, be more readily supervised, but the working areas were so large that they could not possibly be worked out within the year. Consequently, they were abandoned after the eyes had been picked out of them; whereas, under the old monthly permit system, the felled patches were so small and scattered that they stood a better chance of recovery.

In 1906 the reserved area was almost doubled by the addition of the mainland swamps, and in 1908 they were included in a working plan compiled by Mr. J. P. Mead. A careful study was made of the requirements of the fishermen in the way of stakes and poles, and three methods of dealing with the problem were considered, *viz*:

(*a*) Supplying all requirements from one working circle.

(*b*) Setting aside special pole coupes in each of the three circles.

(*c*) Supplying from thinnings conducted under departmental supervision in the firewood areas.

The first of these was discarded as being unnecessarily hard on fishermen who did not happen to live in the vicinity of the selected area; the last was reluctantly abandoned as an unattainable ideal for which our organisation was not then ripe. Pole coupes were, therefore, set aside in each of the three circles, the total devoted to this purpose being rather more than 6000 acres. Within these coupes standards were selected and marked, anything not so distinguished being removable.

After deduction of the areas set aside for pole production the determination of the firewood coupes followed the lines of the island plan, a single yearly cutting area being selected in each of the three working circles. This plan was supported by rough analyses of the growing stock, and an estimate of the probable yield was made on the basis of a 20 year rotation and an average yield of 244 *pikuls*,* or about 14½ tons, per acre. Compare this with the average figure of 1200 *pikuls* (about 72 tons) that has been adopted under the scheme for determining the coupe premia, and which is referred to in Appendix C.

These two plans continued in force until 1913, when Mr. Mead undertook a detailed examination of a large number of old working areas and reported on the results of the previous ten years' workings.

* 1 pikul=133⅓ lbs.

This was followed by a paper submitted to the 1915 Forest Conference, in which attention was called to the urgent need for revision of the existing plans. Unfortunately, owing to the outbreak of war and the shortage of officers, it was not possible to follow up these recommendations in detail, though in the years that followed a number of them were adopted.

Mr. Mead's recommendations are summarised as follow:

(*a*) Rotation to be increased to 25 or 30 years.

(*b*) Fishing stakes to be supplied from thinnings supervised by the staff.

(*c*) Minimum felling girth to be fixed at 12 inches, with 24 inches for *tumu*.

(*d*) Retention of 15 standards per acre, to act as seed bearers.

(*e*) Planting up of unregenerated blanks.

(*f*) Necessity for improved maps and more detailed survey.

(*g*) Seeding fellings to be carried out.

(*h*) Better utilisation to be insisted on.

In 1924 the position was again reviewed by Mr. Sanger Davies, and the extent to which Mr. Mead's suggestions had been adopted and had justified themselves in the intervening years is indicated below:

(*a*) Rotation was increased to 25 years in 1915. This had since proved insufficient.

(*b*) Marking of fishing stakes by the staff had proved impracticable.

(*c*) Minimum girths were not strictly enforced until 1924, when a 15 inch limit was introduced for all species with the exception of *lenggadai*.

(*d*) The standard system had not proved an unqualified success, for the reasons stated on page 172.

(*e*) Planting had justified itself over small areas, but not on a large scale. Crabs had proved very troublesome in places.

(*f*) Surveys and plans had been vastly improved.

(*g*) Seeding fellings had proved impracticable.

(*h*) More complete exploitation had been achieved by better supervision and (since 1917) by the insistence on the removal of everything over 8 inches in girth.

Other changes that had been introduced between 1913 and 1924 were:—

(i) Sub-coupes* reduced in size in 1917, and sub-divided to ensure more thorough exploitation.
(ii) Introduction of royalty system in addition to premium in 1916/18.
(iii) Reopening of partially worked out sub-coupes in 1918/20 to relieve the firewood shortage.
(iv) Abandonment of the old cumbersome working circles in 1918.
(v) Departmental purchase, and control of sales 1918/21.
(vi) Fixed royalty without premium 1922/23.
(vii) Establishment of sample plots to determine rates of increment and other silvicultural data.

In 1924 Mr. Sanger Davies (45) produced the working plan now in force for the Perak mangrove forests. It is recognised that this plan is only tentative, and that it may have to be considerably modified after a few years. It had to be prepared in the absence of reliable stock maps and before the aerial survey had corrected a number of errors that could not be seen from the ground. The position was further complicated by the incomplete exploitation of the past, and by the reopening, during the war, of unworked portions of indefinite shape and size in the old sub-coupes.

The plan assumes three main age classes, *viz*:—

(1) Areas worked prior to 1904 are ready for cutting between 1924 and 1929.
(2) Areas worked between 1904 and 1910 will be exploitable between 15 and 25 years from 1924.
(3) Areas opened since 1910 and subsequently reopened in 1918/20 are considered to have been 3 years old in 1924.

The rotation is raised to 40 years, this figure representating the period of greatest volume production, the calculations having been based on figures which, though admittedly approximate, were sufficiently accurate to justify the adoption of this rotation rather than the arbitrary ones in use hitherto, and which have since been confirmed. The arguments in favour of this period are given in some detail on page 164.

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* *Sub-coupe.* A sub-division of the annual coupe, consisting of one or more compartments, for convenience in exploitation (Rambaut.—*Forest Conference Proceedings* 1926, page 93, (10)).

There are no permanent compartments in the mangrove felling cycle, chiefly because of the constantly fluctuating area and variations in completeness of regeneration. Sub-coupes are selected on their merits, and are grouped to facilitate supervision.

The chief recommendations under this plan are given below. Some of them have been slightly modified for the reasons stated in each case.

(*a*) Size of sub-coupes limited to 200 acres as a maximum, with further subdivision to ensure better exploitation (see page 210).

(*b*) Sub-coupes should be grouped within the three working circles to facilitate supervision.

(*c*) Royalty to be charged at State Land rates in addition to premia to be decided by sealed tender. (This has since been modified as described in Appendix C, the premia being fixed by the forest department),

(*d*) A minimum felling girth of 18 inches is recommended, but one of 15 inches was actually adopted. (This system has been largely discarded in favour of that referred to on page 181).

(*e*) Fishing stakes are allowed to be taken from any part of the forest not definitely prohibited—*e.g.*, sample plot areas and firewood coupes actually allotted,—whilst house posts may be taken on payment of commuted royalty from specially demarcated areas behind the villages.

(*f*) Extensive thinnings to be carried out by the "stick" method. (See page 171). It is likely that it will be possible to induce the fishermen to collect their fishing stakes by this method and to submit to more control than is possible under (*e*) above.

(*g*) Examination of coupes two years after completion of felling with a view to deciding on the necessity or otherwise for planting unregenerated blanks. (It is hoped that this will prove unnecessary now that the staff is being trained to take better care of regeneration).

(*h*) Survey and plotting of interior details as the coupes are opened up. (Systematic accurate survey has not yet been organised on these lines, but the supervising guards have to maintain reasonably clear sketch-maps of the coupes, whilst the plotting of the more important interior details is invariably undertaken as a preliminary to the valuation of the unallotted areas).

A similar plan, identical in all but unimportant details, has since been adopted for Selangor.

(*c*) THE ROTATION.

The main object of management being the production of the greatest possible volume of firewood, and the value of the wood being independent of the age and size of the trees that produce it, the correct felling age will be that at which the mean annual increment reaches its maximum; in other words, the rotation should be that of the greatest volume production.

There are, however, complications, not the least of which are the different requirements and rates of growth of the various types of mangrove, and our present comparative ignorance of their behaviour under artificial conditions. It has already been shown that there is a more or less definite sequence in the development of the species under normal circumstances, and in the case of the Kuala Kurau Avicennia-Bruguiera forests described on page 135 there is a good example of retardation of natural development brought about by measures that were intended to hasten it. Similarly, there is some doubt as to whether the increasing proportion of *lenggadai* (*Bruguiera parviflora*) which has followed intensive cuttings, particularly in Selangor, should be regarded as a retrograde or a forward movement, since it is uncertain whether *lenggadai* normally precedes or follows the rhizophoras. *Tumu* (*Bruguiera gymnorhiza*) reaches its optimum development in the drier parts of the swamps, where they are approaching dry land conditions, but it starts sporadically throughout the mangrove in mixture with the rhizophoras. Is the felling of bakau going to encourage the *tumu*, or will it check its development in the way that the spread of the *berus* was checked by the cutting and girdling of Avicennia at Kuala Kurau?

Such growth statistics as are available are given in Appendix B and show that there is considerable variation. What the figures do not show is the comparative longevity of the different species, of which we know little except that *lenggadai* is likely to die within 20 to 30 years; whilst *tumu*, judging from its rate of growth, the size it grows to, and the patriarchal appearance of some of the old "left overs", will live to several times that figure. Other species appear to occupy intermediate positions.

Rhizophora conjugata (*bakau minyak*) being the predominant species, the rotation should be decided primarily by the age at which its mean annual increment culminates. Sample plot figures indicate that this happens round about its 41st year, at which age the average girth should be in the neighbourhood of 27 inches. Details will be found in Appendix B. Experience has shown that trees of this girth are easy to split and that the exploitation of areas so

stocked is usually reasonably complete, whilst large trees are frequently abandoned on account of the trouble of conversion. It is possible that the growth acceleration that follows heavy thinnings will necessitate a revision of this estimate in due course, though this has to some extent been discounted by rejecting the figures for all but the dominant trees. For the present, at any rate, the arguments in favour of a 40 year rotation appear to be sound as far as both species of Rhizophora are concerned. As regards the others; there would appear to be no useful purpose served by encouraging *tumu* (*Bruguiera gymnorhiza*), which is intolerant of the shorter lived kinds, and probably hastens the deterioration of workable forest into unprofitable and unregenerate "*hutan darat*." *Berus* (*Bruguiera cryophylloides*) sometimes dies off unexpectedly; but this seems to be the result of unfavourable drainage conditions, rather than old age, and as its growth is very slow there seems to be no reason to shorten the rotation on its behalf. *Tengar* (*Ceriops Candolleana*) forms an insignificant proportion of the crop in Perak, but seems to be on the increase in regenerated areas in Selangor. It is eagerly sought by fishermen, who prefer its bark to that of all other species, and who take out permits at the rate of $15 per month entitling them to fell and bark trees over 18 inches in girth. No other restrictions appear to be necessary at present.

Apart from *bakau*, the only other species that requires careful consideration is *lenggadai* (*Bruguiera parviflora*), which often forms a very considerable proportion of the crop under a variety of conditions and which, there can be little doubt, is increasing as a result of clear fellings. As already stated on page 142 *lenggadai* is a short lived opportunist species which would in normal circumstances be replaced by the larger longer lived, faster growing, and more shade-bearing rhizophoras. It is not unreasonable to assume that, had we continued to cut on our original 20 year rotation, this tree might have predominated, and it is quite likely that this period is just about the optimum for pure crops. Whether or not it would pay in certain localities to encourage this tree and work it on a short rotation cannot be stated with certainty in the light of our present knowledge, but the problem is worthy of further study.

In favour of *B. parviflora* in comparison with other mangroves are:

(*a*) Ease of regeneration.
(*b*) Its qualities as a nurse to other species.
(*c*) Absence of stilt roots to impede extraction.
(*d*) Fissibility, light weight, and ease of conversion.

Against it are:—

(1) It is an inferior firewood.
(2) The poles are less durable than those of *bakau.*
(3) The bark is deficient in tannin.
(4) Though quick to establish itself it is a slow grower in the later stages.

Crop comparisons can only be speculative in the absence of reliable data. The limited number of available measurements indicate that the rate of growth of the individual trees is much inferior to that of *bakau* of the same dimensions. This may, however, be compensated by a greater number of stems per acre, and by the very much more rapid and complete regeneration of felled *lenggadai* forest, a hiatus of some years over very considerable proportion of the sub-coupes being not uncommon with *bakau.*

All things considered, however, there does not at present appear to be any necessity to interfere with the 40 year rotation that has been adopted throughout the mangrove reserves of the Federated Malay States. It is interesting to note, in this connection, that although Mr. H. C. Hill (24) recommended in 1900 a rotation of 20 years, Mr. A. B. Stephens Forest Officer, Perak, ridiculed the idea and suggested that 100 years would be nearer the mark. Mr. A. M. Burn-Murdoch, the late Conservator of Forests, supported Mr. Stephens' contention that *bakau* was a slow growing tree, but considered that 35 to 40 years would suffice to produce trees of a convenient size for firewood. Other officers were also inclined to agree that Mr. Hill had over estimated the rate of growth. It is not clear why, in the face of these opinions, the 20 year rotation remained in force for so long.

In Manila Bay, where there is a market for small wood, rhizophora plantations are worked on a rotation averaging about 10 years. Further details of this industry will be found on page 176.

(*d*) YIELD.

Although exploitation has been proceeding for a good many years and careful record has been kept of the outturn, if only for the purposes of assessment of royalty, really accurate yield figures are not available on account of the somewhat rough-and-ready methods that have, perforce, had to be employed in some places for bringing the wood to account, and because of the impossibility of making certain that the produce of the different sub-coupes is not mixed up. These difficulties will be better understood after reference to the description of exploitation and transport methods in Chapter VI.

A further complication is to be found in the almost invariable presence in the working areas of so called "*hutan darat*," *i.e.*, inferior forest that is not provided with natural waterways and which carries an uneven and heterogeneous crop of badly shaped and often almost unsplittable stems. Such areas cannot be worked at a profit and are therefore, usually abandoned or, at the best, very imperfectly worked over. It is usual nowadays for such forest to be surveyed and excised from the sub-coupes, though this practice is not entirely desirable in that it tends to discourage the exploitation of the more difficult areas and leads to differences of opinion as to what is profitable and what is not. However, since regeneration would be unlikely to succeed in many such places, their potential value as producers of firewood is small, and it is an open question whether they are not better left under inferior forest, rather than converted into wastes of *piai* fern forming a menace to the entire neighbourhood.

In Appendix B will be found details of countings and measurements taken in a number of small demarcated areas in Perak, and an estimate of the crop in a 10 acre block of average rhizophora forest about 20 years old selected for treatment under the two-storied system.

All of these figures err on the high side, because the areas were chosen where the crop was densest and free from noticeable blanks. At present, therefore, they represent possibilities rather than probabilities, though it is likely that as our silvicultural knowledge increases and our methods of management and exploitation become more intensive, the average yield will approach or even surpass that of these small sample areas. After all, though chosen for their density and evenness of stocking, they have acquired these qualities in spite of the usual disabilities of overcrowding and a continuous struggle for existence, so that it is not unreasonable to suppose that even better results will follow the more nearly optimum conditions provided by thinnings in the early stages and the better utilisation of light in the lower storey. An average of 75 tons* per acre is, therefore, not likely to be a too optimistic forecast of the future yield from productive areas.†

In the table of yields from actual sub-coupes given below it will be noticed that the Selangor averages are lower than those from Perak. This is because the Selangor forests have been subjected to over-cutting for a longer period, and because supervision and management have, on the whole, been rather less adequate than in Perak. There is now very little mature forest left in Selangor, where a larger proportion of the total area had already been cut over when it was decided, in 1924, to increase the rotation to 40 years; a decision to which, incidentally, full effect has not yet been given.

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* It has been found by actual weighing that stacks of fresh mangrove firewood measuring 50 cubic feet average one ton in weight.

† This is a very modest figure compared with the yields of from 300 to 650 cubic metres per hectare that are said to be possible in some of the old Philippine stands (16). Trees with a diameter of 1.35 metres (6) are without parallel in Malaya.

The following figures summarise the outturn for the past few years. Earlier figures are not sufficiently reliable to be of any value.

Year.	Total out-turn from completed sub-coupes, including former years.	Area of sub-coupes, closed during the year.	Out-turn per acre.	Total out-turn from all sub-coupes during year.	Total revenue from mangrove for whole year.
			PERAK.		
	tons.	acres.	tons.	tons.	$
1919	82,030	1,350	60.76	206,421	965,853
1920	89,658	1,000	89.66	239,529	1,260,355
1921	No figures available			183,110	142,841
1922				148,475	200,125
1923	66,681	786	84.84	151,782	195,655
1924	84,583	1,094	77.32	155,905	207,108
1925	181,250	2,488	72.85	151,314	190,771
1926	81,550	1,083	75.26	164,465	174,964
1927	94,415	1,242	76.82	170,413	129,481
			SELANGOR.		
1917	12,279	458	26.81	46,726	72,566
1918	73,657	1,556	47.34	100,418	100,822
1919	43,111	1,242	34.71	124,848	109,043
1920	32,086	466	68.85	76,610	39,331
1921	21,099	295	71.53	53,084	48,961
1922	51,083	866	58.99	57,984	47,958
1923	87,211	1,475	59.13	66,983	63,942
1924	106,378	1,612	65.99	89,305	76,136
1925	74,026	1,109	66.75	90,904	87,125
1926	98,378	1,231	79.92	104,908	107,331
1927	200,684	3,141	63.89	85,338	83,988

The high revenue figures for 1919 and 1920 in Perak are explained by the system of control that was then in force and which involved a correspondingly high expenditure. (See page 207).

The very large falling off in revenue in 1920 in Selangor and 1921 in Perak was due to the abandonment of firewood in favour of coal on the railway, and to trade depression generally. The falling off in 1927 was the result of reducing the royalty from $4 to $3 per 100 pikuls.

In Perak in 1921 and 1922 the demand was met from old coupes only partially worked in previous years, the areas of which are not known.

(*e*) Silvicultural Systems.

(*i*) **General.** The silvicultural system to be adopted depends primarily on the facility with which the species under consideration can reproduce itself naturally under the artificial conditions induced by forest operations, or on the degree to which it lends itself to artificial regeneration methods. In the remarks that follow the requirements of the two rhizophoras are given priority, but they may be taken to apply with equal force to the other *Rhizophoraceae*, bearing in mind that facility of dispersal depends largely on the size, shape, and buoyancy of the extruded radicle.

Given natural conditions, the reproductive ability of mangrove is high. The main seed crop appears to fall in the third and fourth quarters of the year and to be an annual event, though there are, of course, considerable variations in amount. In addition to the main crop, sporadic fruiting occurs during most months of the year. For all practical purposes it may be assumed that there will be in any two successive years an adequate supply of seed to regenerate any area that is likely to be felled under any reasonable working scheme.

The habit of germinating whilst still attached to the parent tree, combined with the absence of serious enemies above ground and the invariable presence of abundant moisture, give the rhizophoras a great advantage over inland trees that have to adapt themselves to constantly changing conditions. This advantage is, however, to a very great extent discounted by the general unwieldiness of the seed. Vivipary certainly gives the seedling a useful start, provided that it straightway finds conditions suitable for further development, but it does so at a sacrifice of efficiency in other directions. A *bakau* seed is well adapted to establish itself beneath the parent tree, if it happens to fall at a state of the tide when it can plant itself in the mud, but it is not nearly so well suited to water dispersal. True, the seeds retain their vitality for a long time, and the percentage of survivors is high, but the long radicles are liable to be caught up on any projection that they encounter and are completely prevented from reaching felled areas where there are accumulations of slash. With objects of such awkward shape and large size, water dispersal cannot be anything but irregular. In the dryer areas it fails, of course, entirely, except for those species that have seeds small enough to be distributed by surface water after heavy rain.

None of the useful species have any coppicing powers to speak of, in which respect rhizophoras can aptly be compared with conifers. Very young seedlings are, however, not necessarily killed if their tops are broken off, and may be relied upon to recover from ordinary felling damage in sufficient numbers to re-stock

any area on which they were reasonably abundant before felling started. Foxworthy (16) records that in the privately owned short rotation mangrove plantations in the Philippine Islands (see page 176) it is a common practice to split the terminal buds in order to induce the seedlings to fork. Saplings that have begun to branch are generally unable to recover if badly broken, so that, notwithstanding the comparative hardiness of the seedlings, it may safely be said that the rhizophoras are by no means ideally adapted to reproduce themselves under artificial conditions and that, before any considerable area is felled, it is desirable to take steps to ensure that regeneration is already present or, at any rate, reasonably certain to follow.

The writer does not agree that felled wet areas can be relied upon to regenerate themselves without assistance, though their chances of eventually doing so are, of course, greater than those of the dry places, where water dispersal is impossible and the competition from *piai* fern is much more severe. Unless regeneration is already on the ground, or the trees bear or have just dropped a mature crop of seeds at the time of felling, wet areas are likely to remain bare for some considerable time, and their re-stocking will never be anything but patchy. The belief is prevalent that, provided inundation is frequent, seeds will find their way in. Apparently they are also expected to spread themselves evenly wherever there are gaps, much as air will rush in and fill up a vacuum. This optimism with regard to wet mangrove should be checked.

(*ii*) **The selection system.** Though ideal from the point of view of regeneration this system can be dismissed at once as unsuitable on account of transport difficulties and the comparatively low value of the wood.

(*iii*) **The shelter-wood system.** Regeneration beneath the parent tree being the natural method of reproduction of the mangroves generally, the shelter-wood system would appear to be ideal, particularly since the introduction of the "stick" system of thinnings, whereby licensees and others are allowed to remove poles, provided that there is one of the same or superior class and quality within the radius of a stick, the length of which is fixed according to the density of the crop. Areas so treated show satisfactory natural regeneration and an apparent increase in the volume of the trees that remain, more than sufficient, it is anticipated, to compensate for the reduction in the number of stems. A certain

proportion of the poles so taken is converted into firewood, particularly in Selangor. It is, unfortunately, not yet possible to bring sufficient pressure to bear on the main consumers—the fishermen—to carry out these controlled fellings to the extent that is desirable. Steps are, however, being taken to achieve these objects and thus to lead the destructive energy of these somewhat obstinate people into useful channels.

The idea of stick thinnings was inspired by an article by "Trowscoed" in the *Indian Forester* for November 1921 (Vol. XLVII page 453) the scheme being modified by Mr. A. E. Sanger-Davies to suit local mangrove conditions. The general idea is to carry out two thinnings and a regeneration felling during the 40 year rotation, the first thinning being made as soon as anyone can be found to carry it out, the second about 10 years later, and the regeneration felling about 2 years before the area is due to be cut over. The length of stick for the three operations was originally recommended as 3′, 6′, and 8′ respectively, the probable ages of the stands so treated being approximately 20, 25, 30/35, and 35/38 years.

In practice it has been found that the 3′ stick does not permit of the removal of enough poles to make it worth the cutters' while. By the time the trees in a closed stand have reached marketable size, self-thinning has reduced their number to little more than the 1210 which would theoretically be left if a stick of this length were used. It has, therefore, been decided to increase the length of the stick to 5′ or even 6′ for the smaller classes, whilst 7′ is recommended for the older classes, though these lengths may be modified to meet special cases. *Bruguiera parviflora* (*lenggadai*), for instance, is considered by some to be unable to stand up to thinning with anything longer than a 5′ stick, whilst 7′ may be found too short for well grown Rhizophora. The length of the stick to be used for the regeneration felling will depend primarily on the canopy and the existing regeneration. It must be remembered that these thinnings are not carried out departmentally, but are commercial undertakings on the part of private contractors. In deciding the length of stick to be adopted it will, therefore, often be necessary to sacrifice silvicultural ideals and to modify the thinning programme to suit local market conditions. Stick thinnings are, at the best, in the nature of a compromise, the efficacy of which depends so largely on conditions that are outside the control of the administering officer that it would be unwise to attempt anything but a very elastic policy with regard to them.

At the risk of stating the obvious it may be mentioned that the effect of the stick is to establish an interval of approximately double its length between the remaining trees. In theory it should be rather more, since measurement is from circumference to circumference, and not from centre to centre; in practice it is often less, because of the anxiety of the contractors to avoid friction with the department. There is usually a tendency on the part of subordinates to be unduly severe, and to penalise the cutting of trees that may be slightly outside the prescribed radius, but the removal of which may actually be advantageous. It is better, therefore, to make a careful inspection of the area before inflicting a fine, and not to punish at all if the offence has been merely trivial.

(*ii*) **High forest with standards.** As already stated on page 161, the retention of standards has not found unqualified favour, mainly because of the heavy mortality due to windbreak and lightning. *Bakau* grown in closed forest is as susceptible as most other trees to sudden isolation, whilst its power to withstand sudden gales from the sea is not assisted by the unstable nature of the soil in which it grows. It has also been observed that even the surviving standards have failed to perform the functions for which they were retained, whilst the fallen ones have done a disproportionate amount of damage to the already inadequate undergrowth. Finally, it has been pointed out that the amount of royalty sacrificed by the retention of these standards would have been more than sufficient to pay for replanting the whole area.

There is a good deal to be said for these arguments, and there can be little doubt that, as practiced in the past, the standard system has failed to come up to expectations. But consideration of the steps taken to achieve the desired results throws a very different light on the matter. Although, theoretically, the selection of the standards has been done by the forest department, the subordinates actually concerned have, not unnaturally, been largely influenced by the likes and dislikes of licensees and have, therefore, allowed a large number of over-mature and otherwise unsuitable trees to be retained, some of them even being of undesirable species. Such standards can scarcely be expected to stand up to wind pressure without the support of their neighbours, and they are probably past their prime as far as regeneration is concerned; moreover, it is obviously unreasonable to expect an already over-mature tree to survive a second rotation.

It seems, therefore, that the standard system has not been given a fair chance, and that better results would be likely to be achieved by retaining a considerably larger number of smaller standards. These would be better able to resist the wind, would be



58. Natural regeneration of *Bruguiera caryophylloides* (BERUS) in a gap in unexploited forest.



59. BERUS. (*Bruguiera caryophylloides*). Natural regeneration after clear felling.



60. Natural regeneration after thinning. The lenticellate stems are of TENGAR (*Ceriops Candolleana*); the others are of LENGGADAI (*Bruguiera parviflora*). Note pneumatophores in foreground.



61. BAKAU (*Rhizophora spp.*). Natural regeneration under standards.

less likely to be struck by lightning, would be more likely to produce an adequate crop of seed and to distribute it more regularly over the area, could reasonably be expected to survive a second rotation, and need not involve any appreciable loss of royalty. It has been recommended that, wherever possible, such standards should be left in groups of two or three rather than as isolated stems. The best answer to the suggestion that the royalty on standards would more than cover the cost of planting is to be found in section (*vii*) of this chapter, where the position is discussed, and the conclusion is reached that planting on a large scale is impracticable.

(*v*) **Two storied high forest.** The chief disadvantages of the shelter-wood system are the inability of mangrove saplings to recover from damage caused by the removal of the main crop or to survive for long under dense shade. Natural regeneration of mangrove under shade is generally easy to accomplish, but it is a most difficult thing to preserve in its later stages. For this reason, a modification of that system has been suggested, whereby the thinning would be much more severe and the regeneration would reach the pole stage before the removal of the main crop. The poles should have their crowns sufficiently far into the upper storey to enable them to survive felling damage in large enough numbers to replace the main crop. On the assumption that a fully stocked forest carries about 400 stems to the acre, the system might be introduced by the removal from a 20 year old stand of all but 200 of the best stems. At the end of a 40 year rotation there should be almost this number of mature trees, with a slightly lower storey that ought to be able to survive the removal of the upper storey better than the delicate sapling undergrowth induced by seeding fellings. The drastic thinning in the middle of the rotation should result in an increased girth increment that would more than compensate for the heavy removal of immature (and possibly unsaleable) poles, and the result might well be a crop every 20 years little inferior to the present 40 year yields.

It is, of course, quite possible that, in practice, the lower storey might not come up to expectations, or that losses in the upper storey might be unduly heavy. The system is now being tried over 10 acres in Perak, particulars of the volume of timber removed and still standing being given on page 246. It is still too early to express an opinion on the success or otherwise of this experiment, but it can safely be said that the appearance of the lower storey is encouraging. It is thought, however, that too many stems have been left and that the canopy will soon close up again, in which case the regeneration will probably be more vulnerable than if it had been induced by a seeding felling immediately prior to felling.

(*vi*) **The minimum girth system.** This is really a development of the standard system, whereby the smallest trees are retained, instead of the largest. A 15 inch girth limit is still enforced in many of the coupes, particularly in Selangor, where it gives satisfactory results in forests that are, on the whole, rather immature. Heavy fines are enforced for non-compliance. The disadvantages are chiefly those attendant on any silvicultural measure relying on rule-of-thumb methods. Stems of the required girth are not necessarily present in the desired proportion. They may be entirely absent from mature forest, whilst elsewhere there may be far too many of them. As a temporary measure this system may be said to have proved fairly satisfactory, though it has undoubtedly done a good deal of harm in some of the over-aged areas in Perak.

(*vii*) **Clear felling and planting.** This system is not recommended. Even if it had no other disadvantages it would be ruled out by the enormous expense. It would never be possible to rely on sufficient labour at a time when there was enough accessible seed to carry out extensive plantings. Bakau can be, and is, planted where natural regeneration has failed, but only on a comparatively small scale.

A special form of clear felling and planting is practiced in Manila Bay where, according to Foxworthy (16) the cultivation of mangrove (chiefly *Rhizophora mucronata*) has formed a private industry for at least three generations. The following facts are taken from Foxworthy's report:

The most suitable soil is freshly deposited mud by the side of a stream, but dryer areas are also planted. After thorough clearing of all undergrowth the seedlings are thrust into the mud at intervals of from 40 to 100 centimeters, 40 to 60 centimeters (or say 18″ to 2′) being the most usual spacing. Young plantations are protected from damage by floating objects by a fence of branches, a hedge of Sonneratia, or by the retention of a protective line of older trees along the river bank. Blanks are supplied after the first year; thereafter tending consists of an occasional cutting of creepers, though these are usually insignificant. Where planting is considered to be too wide the terminal bud is split, during the second year, to induce forking and better utilisation of the growing space.

The very small interval between the plants induces self-pruning in from 7 to 12 years after planting, when the crop is considered to be ready for cutting. Though the planters agree that wider spacing would induce faster growth they do not believe that it would pay them. Foxworthy considers, however, that the planting interval could probably be doubled with advantage.

The yields from three plantations are tabulated by Brown and Fischer (6), two seven year old areas yielding at the rate of 92 cubic metres per hectare (1315 cubic feet, or 26 tons, per acre) whilst one eight year old area produced 147 cubic metres per hectare (2100 cubic feet, or 42 tons, per acre).

Comparisons with local yields are not possible because little of the produce of these plantations would be marketable in Malaya. The yield figures in Appendix B do not take into account anything with a smaller girth than 8 inches, whilst in the tables quoted above the *maximum* diameter class in the older plantation is 12 centimetres (say 16 inches in girth) and the bulk of the crop falls in the 4 and 5 centimetre diameter classes, *i.e.*, roughly between 4½ and 6 inches in girth.

Though it is not likely that plantations run on these lines would be profitable in this country, it is thinkable that in the neighbourhood of Singapore, where there is a large market for small kindling wood known locally as *likau*, some modification of the Manila industry might prove successful.

Reference has already been made to the dangers to which seedlings are exposed and the desirability, for this reason if for no other, of securing adequate natural regeneration under cover. Where, however, it has been decided that planting is necessary, care should be taken to select healthy seed for the purpose, and to use only those that have recently fallen from the trees, or that will come away without pulling. It is advisable to reject the sporadic and early seeds and to wait until there is no doubt of the ripeness of the main crop, which is not only more vigorous, but which in the case of *R. conjugata*, ripens at a time when the weather is usually cooler and wetter.

Bakau minyak, being the predominant and most valued species, is usually planted, but it is desirable to use other kinds rather than to leave the more urgent parts of the planting programme for another year, during which time many things may happen. *Bakau kurap* produces ripe seed earlier in the year and might, therefore, be used for supplying blanks in plantations of *B. minyak*. Mixed plantations are, at any rate in theory, less liable to be damaged by crabs, and they are in principle better forestry than those consisting of only one species. Another advantage of using species other than the rhizophoras is that their radicles are smaller and can, therefore, be handled in quantity more easily. Mixtures of *bakau* and *lenggadai* produce the heaviest crops in the mangrove, and are worth encouraging. *Tengar* is said to be immune from attack, but is not always obtainable. The planting of *tumu* is not recommended.

A good planting distance is 6′ by 6′. The seeds should be stuck in to a depth of a few inches only, so that they will not fall over; deep insertion is not recommended. Planting on contract is convenient, but the contracting parties must be reasonable over

supplies, and the forest officer must be prepared to take over the re-stocking of places where crabs have proved troublesome in spite of a fair number of supplies by the contractor.

It has been reported that broken-off portions of radicles will grow into trees, and the suggestion has been made that such pieces might be sown broadcast. Though some of the species possess this property to a limited extent, it has no practical application.

Attempts to transplant rooted plants of *bakau* and *lenggadai* have been made on several occasions but have only been partially successful. It was thought that such transplants might provide a solution to the crab problem, and enable natural regeneration to be assisted at low cost where the self-sown seedlings were irregularly distributed. The survivors were, however, not sufficiently numerous, in spite of great care in planting and exceptionally favourable conditions of soil and moisture.

(*viii*) **Clear Felling and Natural Regeneration.** The reproductive ability of *Bruguiera caryophylloides* has been discussed on page 141. In the Banjar Reserve, near Kuala Selangor, where pure stands of this species occur, sub-coupes are demarcated in the form of long strips running more or less at right angles to the road which forms the landward boundary of the forest. In these strips, which are narrow enough to be adequately served by a single canal or line of rails running down the centre, no precautions are necessary to ensure adequate regeneration. (See illustration page 173).

It is quite likely that strip fellings would give good results in Rhizophora forest, though it must not be forgotten that seed dispersal is there dependent on the tides, and not, as in the *berus* forests, accomplished by the agency of rain water or, to a limited extent, by wind. Any attempt to introduce this system in the wet mangrove would, however, be complicated by transport difficulties.

(*ix*) **Coppice.** As already stated, none of the *Rhizophoraceae* are able to regenerate themselves by coppice shoots, though this power is possessed to a limited extent is by some of the inferior species. Troup (50) states that working plans in Madras prescribe coppice fellings for mangrove under rotations of 5 and 10 years, and that large trees are capable of producing vigorous pollard shoots. It seems probable that the author referred to plans for the Coringa (Godavari) mangrove, for the loan of which and the relevant correspondence I am indebted to Mr. R. D. Richmond, Acting Conservator, Madras. These forests appear to be stocked with almost pure Avicennia (*api-api*) which, even in Malaya, possesses coppicing



62. Plantation of *Rhizophora conjugata*, $2\frac{1}{2}$ years old.



63. RHIZOPHORA plantation 4 years old. Left, *R. mucronata* ; right, *R. conjugata*.



64. Plantation of *Rhizophora conjugata*, 13 years old.

powers that are superior to those of other mangrove species. It seems that this peculiarity led to the assumption that regeneration, which was actually being accomplished by seedlings, was the result of coppicing, and further that an erroneous estimate of the rate of growth resulted from the measurement of old stems that had been left over from previous fellings, but credited with the age of the subsequent regeneration. Since the appearance of Troup's book, the plans have been completely revised, a *minimum* rotation of 20 years has been adopted, and the coppice system has been definitely repudiated.

(*x*) **Conclusions.** Experience in the past has shown that it is not possible to devise any single system that will satisfy the silvicultural requirements of all types of mangrove forest. The tendency has been to attempt to protect the forests by means of fines for non-observance or breaches of rules. Such fines have usually, however, but little value as deterrents and are, as often as not, equivalent to locking the stable door after the horse has been stolen. Moreover, they tend to raise the price of firewood. It is, therefore, considered desirable to allow the subordinate staff a good deal of discretion in the control of fellings and to train them to enforce a few simple rules which, though by no means perfect, should ensure sufficient natural regeneration. During the past three years the men in charge of the felling areas in Perak have been instructed on the following lines:

(1) Examine existing regeneration before felling starts. If it is adequate, see that it is protected from damage as far as possible.

(2) Where there is adequate regeneration on the ground it is not necessary to retain any standards.

(3) If there is insufficient regeneration, examine the trees that are to be felled. If they carry a crop of mature seed they can be relied on to scatter about enough to seed up the area, and no standards need be retained.

(4) Where there is much *piai* fern in the undergrowth it is advisable to retain a few standards in the worst places, even though there may be regeneration amongst it.

(5) Where there is no regeneration standards must be retained at intervals of not more than one chain.

(6) Standards must be selected with a view to their ability to produce seed and to cover the ground. There is no objection to the retention of badly shaped trees if they are healthy and not too old.

(7) *Tumu* (*Bruguiera gymnorhiza*) is not to be kept if any other useful species is available. The retention of species not belonging to the order *Rhizophoraceae* is forbidden.

(8) Selection of standards should proceed *pari-passu* with felling operations in order that full advantage can be taken of the seed crop.

(9) Accidental damage to standards need not necessarily be punished and can often be remedied by the substitution of other trees. It is necessary to impress on the coolies that it is their duty to call attention to such damage before any more felling is done in the neighbourhood of the damaged standard.

(10) Remember, that it is you, and not the licensee, who will be held responsible for the proper observance of these rules. If you are ever in doubt, or if the coolies will not obey your instructions, consult your superior officer without delay.

The system that is recommended as likely to give the best results is the shelter-wood system, modified as described under (*iii*) on page 170. The above instructions have been devised to safeguard regeneration in forests where the preliminary treatment has not been carried out, or where it has failed to have the desired effect. There is nothing in them that need perplex even the dullest subordinate or that will add a cent to the extraction costs of the licensee. On the contrary, the shifting of responsibility from the licensees to the supervising officer can only be followed by a considerable reduction in the monthly bill for fines and compensation which, under the old system, formed a considerable proportion of the revenue. For the adequate enforcement of these rules it is, of course essential for the supervising guards to live in the immediate vicinity of the sub-coupes, and it may be necessary to increase the subordinate staff to enable closer supervision.

Just as the backbone of the army is the non-commissioned man, so the mainstay of the forest department is the trained forest guard. No amount of inspection on the part of European officers, or fines inflicted on licensees, will result in thorough work and satisfactory regeneration unless the supervising guards have reasonably definite ideas of the silvicultural requirements of the trees and are able to command the respect of the felling coolies.

Chapter VI.
UTILISATION.

No exhaustive examination has ever been made of the commercial value of the mangrove forests of the Malay Peninsula. Local conditions alone have determined the uses to which the different species have been put, all other conditions having of necessity to be subordinated to the pressing demand for firewood and fishing stakes.

The following statement summarises most of the recorded uses, the majority of which are, however, foreign to Malaya. The bulk of the information in this chapter comes from Heyne's "*Nuttige Planten*" (23). The list is by no means complete, but it is comprehensive enough to show that the swamps are rich in minor produce. The writer cannot vouch for the efficacy of the medicinal products. As far as foodstuffs are concerned, various parts of many species are eaten, but few of them are palatable enough to be worth regarding as anything but starvation diet. Most of them have, therefore, been omitted. Practically none of them are valued locally.

(*a*) Summary of Uses.

Acanthus ebracteatus (*Jeruju puteh*).	The fruit of both species is pounded and used as a blood purifier and dressing for boils. A preparation of the leaves is said to relieve rheumatism, and a poultice of the fruit or roots is sometimes applied in cases of snakebite and arrow poisoning.
„ ilicifolius (*Jeruju hitam*).	
Acrostichum aureum (*Piai*).	Used as litter for cattle and for rough roofing.
Aegiceras majus (*Kachang-kachang*).	No local use, but bark is said to contain a fish-poison.
Avicennia alba (*Api-api hitam*).	Inferior firewood and timber where nothing better available. Heart wood of attractive appearance resembling fumed oak. Has been used for smoking rubber. Ashes used for washing cloth. Bark used as an astringent and by tanners. Ointment made from seeds applied to tumours and small-pox ulceration. Sap reputed to be efficacious for birth-control purposes. Formerly used in Burma for water pipes.
„ intermedia (*Api-api puteh*).	
„ lanata. (*Api-api berbulu*)	
„ officinalis (*Ludat*).	
Brownlowia lanceolata (*Durian laut*).	No recorded use.
„ Riedelii.	

Bruguiera caryophylloides (*Berus*).	Firewood, timber. Young radicles occasionally boiled and eaten as vegetable or preserve.
„ eriopetala (*Mata buaya*).	Timber, firewood, charcoal. Radicles as a vegetable. Fruits chewed as a substitute for *sireh*. Medicine for sore eyes from fruit. Scent from pneumatophores. Condiment from bark.
„ gymnorhiza (*Tumu*).	
„ parviflora (*Lenggadai*).	Timber, firewood.
Carapa moluccensis (*Nyireh Batu*).	Timber, firewood. Oil from seeds as illuminant and hair oil. Decoction from bark given for cholera. Pins of wood used in boat building. Said to be used for splitting granite in quarries.
„ obovata (*Nyireh bunga*).	
Cerbera lactaria (*Pongpong*).	Rubbing with the fruit is said to ease rheumatism. Seeds contain a medicinal oil, also used as illuminant. Purgative from bark and sap.
„ Odollam.	
Ceriops Candolleana (*Tengar*).	Timber, firewood. Bark yields useful dye and tan. Decoction of bark said to stop haemorrhage and to be used in obstetrical cases. Calyx chewed as a substitute for *sireh*.
Cycas Rumphii (*Paku laut*).	Starch from pith and seeds. Ointment for ulcers from seeds.
Daemonorops leptopus (*Rotan bakau*).	Tying.
Derris uliginosa (*Setui*).	Weak fish-poison.
Excoecaria Agallocha (*Buta-buta*).	Incense wood. Ruin for skin diseases. Sap and wood have purgative properties. Fish-poison from sap.
Heritiera littoralis (*Dungun*).	Timber, firewood. Ground seeds said to cure diarrhoea.
Hibiscus tiliaceus (*Baru laut*).	Rope from bast fibre. Young leaves eaten as vegetable. Ground up in water the leaves are said to be useful as a hair-restorer, expectorant, and to relieve retention of urine. Timber used for wheels of carts, etc.
Intsia retusa (*Ipil*).	Timber.
Kandelia Rheedii (*Berus-berus*).	No local use. Bark said to be useful for making a mordant and red dye, and medicinally for diabetes.

Lumnitzera coccinea (*Teruntum*).	Timber. Decoction of leaves said to be used for thrush. *L. racemosa* is rarely large enough to be used for timber, but makes durable fence posts. Used in Siam for *sireh* props.
„ racemosa (*Sesup*).	
Nipa fruticans (*Nipah*).	Leaves for thatch; fruit for preserve; young leaves for cigarette wrappers; sap for sugar, alcohol, and vinegar.
Oncosperma filamentosa (*Nibong*).	Piles, house-posts, flooring, fish-traps, thatch-binders, shuttles, etc. The "cabbage" makes excellent salads and pickles.
Pluchea indica (*Beluntas*).	Eaten as vegetable. Infusion of leaves as substitute for tea and as an ingredient in various medicines. Useful mouth-wash.
Podocarpus polystachyus (*Jati laut*).	No recorded use.
Rhizophora conjugata (*Bakau minyak*).	Timber, firewood, charcoal, tanbark.
„ mucronata (*Bakau kurap*).	Timber, firewood, charcoal, tanbark. Decoction of bark said to be used in cases of haematuria. Light wine said to be made from juice of fruit.
Scyphiphora hydrophyllacea (*Chingam*).	Too small to be of much use, but timber is said to be very durable as fence posts and tool handles.
Sonneratia acida (*Berembang, Pedada*).	Fruit edible; made into poultices for sprains etc. Fermented juice said to check haemorrhage. Firewood.
„ alba (*Gedabu*).	Fruit edible; presumably used for same purposes as preceding species.
„ Griffithii (*Perepat*).	Timber, firewood. Pneumatophores for fishing floats and as substitute for cork; fruit not edible.
Thespesia populnea (*Baru, Waru*).	Rope from bast fibre. Timber small but of good quality. Heart wood has medicinal qualities. Ointment from fruits said to kill lice. Decoction of leaves for headaches and scabies.

(*b*) UTILISATION AS TIMBER.

As producers of sawn timber the mangroves and associated species are, at present, of little importance, though some of them furnish useful woods. None of them are likely to reach timber size on a rotation of 40 years. If any are considered worth encouraging they will have to be given special treatment.

Teruntum (*Lumnitzera coccinea*) provides one of the most useful timbers. It is extremely durable, stands immersion in water, and is said to be immune from attacks of teredo, being consequently specially suited for piles and for wharf and bridge building. Large trees are now, unfortunately, so scarce that the demand for it has practically ceased. It is recorded by Heyne (23) that pier posts of this timber were intact and difficult to cut after 20 years' exposure at Banca, whilst others, at Riau, were still sound after 50 years. The wood seasons and keeps its shape well, and as it is fragrant and of attractive appearance it is particularly suitable for cabinet work. It is classed as a rose-wood.

Bakau (*Rhizophora spp.*) The wood of both the Rhizophoras shows a beautiful silver grain when cut in radial section, but its weight, poor durability of the sapwood, and comparatively small girth, preclude its utilisation in the form of sawn timber except on a very small scale in the vicinity of the mangrove swamps. It is, however, in considerable demand for piles and for the framework of houses in fishing villages. The Malays of the east coast assert that sound timber from naturally dead trees is much more durable than that from trees felled whilst still living, however well the latter may be seasoned. Heyne (23) states that the heart-wood of *R. conjugata* is the more durable of the two, but that it must be carefully seasoned.

The Bruguieras. None of the Bruguieras are used for timber to any great extent, though the wood of one of the species is said to last well in wet situations and to be resistant to insect attack. Brown and Fischer (6) credit **tumu** (*B. gymnorhiza*) with 8 years of resistance to teredo attack, a figure that would place it very high in the list of timbers that are able to withstand this pest.

The foregoing and *B. eriopetala* **(mata buaya)** are two of the largest of the mangrove species, and on this account, and owing to their unsuitability in the larger sizes for conversion into firewood, they deserve more consideration as timber trees. Unfortunately, the wood is hard to saw, is heavy, and seasons badly unless carefully protected from the weather. Heine (23) recommends seasoning in a vertical position to enable the water to run off quickly, a method which suggests the advisability of girdling before felling. *B. caryophylloides* **(berus)** is valued somewhat highly for house posts, and

poles of this species from which the bark has been removed by beating them with a heavy mallet are used as rafters in thatch roofed houses. *B. parviflora* (**lenggadai**) is looked upon as inferior to the others, but is said to be used as a mining timber in British North Borneo.

Tengar (*Ceriops Candolleana*) does not usually grow to a large size, but its bent branches are often used as knees for boat building, and the stems for house posts. It is regarded as the most durable of all true mangroves. In Pulau Laut it is (according to Heyne (23) used in large quantities for pit props in the coal mines.

Api-api (*Avicennia spp.*) None of the species are cut for timber if anything better is available. It is said that in the Dutch Indies (1) and the Adamans (18) the wood is used for making rice mortars, the rough grain on the transverse section greatly assisting the process of decortication. In Burma, logs have been used for water pipes (38). The heartwood of old trees is described as hard, heavy, of a purplish colour and attractive grain, and suitable for cabinet making. The younger wood is slightly greenish or bluish and somewhat resembles fumed oak. The largest trees recorded locally are of *A. lanata* on the east coast, one of which measured over 10 feet in girth at breast height, with a straight bole that should furnish some useful sized timber.

Perepat (*Sonneratia Griffithii*) grows to a large size and yields a hard timber which is occasionally used for house posts and also in boat building. It is useful for piles and bridges, as it is resistant to teredo attack, but it has a grave disadvantage in that it contains a large proportion of salt which corrodes iron spikes and bolts. For constructional work the use of copper or heavily galvanised iron is therefore necessary. Becking and Berger (1) record that sleepers of this wood are being used experimentally on railways in the Dutch Indies. The other Sonneratias are of no significance as timber trees.

Nyireh *Carapa moluccensis* (**nyireh batu**) produces an attractive timber which closely resembles mahogany in appearance and texture. The wood is excellent for cabinet making, keeping a good shape and taking a fine finish. A large number of articles of furniture have been made in the workshops of the forest department, and it is a great pity that the supply of this timber is not nearly equal to the demand. The cultivation of the species in dry mangrove areas is well worth considering. Ridley (41) records its use for large sized beams in Setul, where it appears to be a good deal commoner than in the F.M.S. *C. obovata* (**nyireh bunga**) is much more abundant than the foregoing species but it is practically never obtainable free from knots and hollows. It has no local value as a producer of timber.

Dungun (*Heritiera littoralis*). Unlike the *sundri* (*H. minor*) of the Sundarbans and other Indian and Burmese mangrove swamps this species is of little importance for timber, though the wood is of extremely good quality and in demand for rice-pounders and similar domestic articles. It usually forms only a small tree with a crooked stem which branches low down and precludes its use for any purpose where even moderate size is required. It is, moreover, by no means common.

Nibong (*Oncosperma filamentosa*) is one of the most useful trees of the mangrove belt. The stems are used whole for house and bridge posts and split for flooring, decking, fish drying platforms, backbones for nipah attaps, roof gutters, water pipes, and a variety of uses too numerous to mention. Although strong enough when fresh, and fairly durable, the soft pith rots away after a time leaving a mere shell, outwardly sound but likely to give way without warning. The outer portion is sometimes used for small pieces of furniture and has a pleasing appearance.

Ipil (*Intsia retusa*) provides a good quality timber similar to the inland *merbau* produced by *I. Bakeri*. It is, however, rarely used locally, as it is not usually particularly accessible.

(*c*) UTILISATION FOR FISHING STAKES AND SCAFFOLD POLES.

The methods employed along the coast for catching fish on a large scale differ in detail, but in principle are all the same. Converging rows of stakes or some similar device lead towards a net or trap into which the fish can enter but from which they are unable to escape. The outer stakes are not necessarily closely set and it is quite possible for the fish to swim between them, but the disturbance created by them in the water and the vibration set up in them by the current attract the fish and induce them to follow up the line of stakes until they are imperceptibly carried by the current into the trap proper. The poles used vary in girth according to the nature of the trap, and in length according to the depth of water.

The requirements of a good fishing stake are durability in salt water, combined with straightness and sufficient length. The rhizophoras are generally preferred, though *Bruguiera parviflora* (*lenggadai*) is much used in Selangor for the construction of *jeremals*. The other bruguieras are sometimes used by Chinese, (but not, it is said, by Malays) for *ambai*, though only when nothing else is available. Even Oncosperma (*nibong*) is used where it occurs in sufficient abundance. To some extent prejudice determines the species to be employed. For

example, *B. parviflora* is regularly used in Selangor, but is regarded with little favour in Perak, while the unpopularity of *B. caryophylloides* in both places is attributable not only to its alleged inferior durability (which seems doubtful) but to its peculiar odour, which is said to scare away the fish but which might be expected to disappear within a short time in the water.

Fishing stakes ordinarily last about 9 months, and in the most favourable circumstances not more than two years. In any case, the traps require constant patching, and it is not unusual for storms to destroy them altogether. The number of traps runs into many hundreds, and of fishermen into some thousands. Bearing in mind that the stakes are all of selected material, and that not only the traps, but the fishermen's houses, are constructed and maintained from the produce of the mangrove swamps, it follows that this industry involves a considerable strain on the resources of the forest. In the neighbourhood of the principal fishing grounds difficulty is experienced in providing for the needs of the fishermen. The steps taken to safeguard this supply and to utilise the demand to benefit the forests are described in the chapters on Silviculture and Management.

(*d*) Utilisation for Firewood.

Firewood, which is extracted in billets varying in length from 17 inches to 5 feet, and in weight from 3 to 35 lbs., according to the use to which it is to be put, is by far the most important product of the mangrove forests and, in spite of competition from other fuels, is still in great demand for domestic use, for the tin-mines, and for small steam vessels. Until the discovery of coal in the F.M.S., and particularly during the war, the demand was far greater than the supply, but the position is now considerably easier and the demand in Perak can be met without the necessity for over working the forest. In Selangor the supply is still inadequate.

As regards its calorific value, experiments have been carried out and tables published from time to time, the most complete being those on page 106 of Brown and Fischer's "*Philippine Mangrove Swamps*" (6). The writer considers, however, that it is not advisable to place too much reliance on figures of this kind because of the tremendous variation that must arise from a variety of causes. Consumers use the fuel best suited to their requirements and, within broad limits, will take what is most readily accessible. With firewood, the proof of the pudding is very much in the eating, and owners of steam engines are likely to be influenced far more by practical experience than by theoretical considerations. The only

safe guide to the heating value of any form of fuel used in external combustion engines of the types commonly employed and under the conditions that usually obtain in this country, is an actual steaming test carried on for a period of at least several weeks under conditions of accuracy that can be approximated to in actual practice. In other words, the test must be an essentially practical one, not likely to be unduly influenced by the personal factor, and sufficiently extensive to rule out the inevitable variations in moisture content, proportions of the different species represented in any particular shipment, size of billets, and the hundred and one other considerations that are likely to influence the behaviour of any fuel that is not homogeneous and that must be stored in the open.

It has been stated that a ton of mangrove firewood is approximately equivalent to 2/5 ton of Indian or Japanese, and to 3/5 ton of Malayan coal. Its calorific value is said by Foxworthy (12) to be higher than that of oak. Experiments made in 1902 by the Public Works Department in Selangor appeared to prove its inferiority to casuarina and other woods commonly used as fuel and lumped together under the name "jungle firewood." It is very doubtful whether this test, which is described on page 292 of the *Agricultural Bulletin* for 1902, was conducted on lines likely to lead to reliable results. "Jungle firewood" is, moreover, composed of an indiscriminate mixture of woods of all kinds, so that its heating value is largely a matter of chance.

Mangrove firewood has the great advantage to the regular consumer that it burns with an even heat, thus enabling him to calculate his requirements and check his consumption with some accuracy. It is also clean, does not create much smoke, and ignites easily when partially dry. It is, therefore, an excellent fuel for domestic purposes, and can be used in any type of furnace, though the salt which it contains is likely to cause trouble in water tube boilers by depositing on the tubes. The makers of such boilers claim, however, that this trouble is by no means unsurmountable and that a device can be fitted which will eliminate it without the necessity for lengthy or frequent stoppages. There seems some reason to believe that mangrove firewood has been abandoned in this class of boiler without having had a really fair trial.

A further advantage of mangrove is its fissibility, which facilitates its conversion. Only the rhizophoras and bruguieras are at present of economic importance as fuel producers but other trees of the mangrove swamps are extracted with them, though an undue preponderance of these species—and even of *lenggadai* (*Bruguiera parviflora*)—is apt to be resented. One of the least popular is

nyireh (*Carapa spp.*) which generates so much heat that granite heated with it and rapidly cooled with water is said by Ridley (41) to split, but which does not maintain an even heat sufficiently long to be of much use for steaming purposes. Its extraction is, however, insisted on in mangrove felling areas, and no difficulty is experienced in disposing of a reasonable quantity of it in mixture with mangrove firewood proper. In places where it is common (*e.g.* Singapore and Johore) it is usually sold at a cheaper rate than *bakau*. The avicennias have little heating power but are sometimes used for smoking rubber or fish, the clean white smoke making it particularly suitable for these purposes.

(*c*) Utilisation for Charcoal.

Mangrove makes excellent charcoal, but owing to the enormous demand for firewood and to the fact that charcoal burners want large timber and cannot be induced to utilise the large amount of scattered material rejected by firewood cutters as unsuitable or unprofitable, charcoal burning is not commonly practised in the mangrove swamps. Another very real obstacle to this industry lies in the constant inundation of the coupes and the trouble that is experienced in keeping the kilns above the high water mark. Most of the high land bordering the swamps has been alienated and, in any case, is not necessarily suitable, as it may be at such a distance from the felling areas that transport costs are excessive. It is however satisfactory to be able to record that a number of kilns have been established within the last few years and that the burners are largely utilising standards that have served their purpose, or over-mature and unsplittable trees left over in some of the old coupes.

Most of the charcoal used in the Federated Malay States comes from the adjacent Dutch Islands, where the demand for firewood is smaller, control is not so strict, and conditions are generally more favourable. For the bulk of the following information regarding the industry in the coast district of Negri Sembilan I am indebted to Mr. D. S. P. Noakes, Assistant Conservator of Forests. Similar methods are practised in Selangor.

The kilns are permanent structures, roughly cylindrical in section with vertical walls about 6 feet high, surmounted by a conical top. They are erected in batteries under the shelter of an *atap* roof. Firm ground is chosen and carefully levelled to form the floor, about which a double framework of wood is erected in which clay is packed to form the side walls. When these are ready, a pole is driven in to the centre of the enclosure and a frame is erected on which clay is laid to form the roof. After this has been

completed and when the clay is thoroughly dry, the wooden framework is removed, leaving a solid structure with side walls about 3 feet thick and a domed roof capable of supporting its own weight with an ample margin of safety. An arched doorway is left at one side for filling and discharging purposes. Five equidistant vent holes about 3 inches in diameter are left at the junction of sides and roof, and two in the roof itself, the former to allow the escape of steam and gas during firing, the latter to provide ventilation when the kiln is being emptied. It is said that an average kiln takes 15 men 15 days to complete and that it may cost as much as $2,000, though this figure can be divided by two if suitable materials are available in the vicinity. The life of a kiln may be 10 years or more, provided that it is kept in constant use. If it is allowed to cool completely it will soon fall to pieces.

The wood used for firing is in the form of round logs about 6 feet long and preferably of as large diameter as it is possible to handle. They must not be allowed to dry out, and the retention of their bark is regarded as essential. They are set up vertically, the largest pieces being towards the centre, and they completely fill the whole of the cylindrical portion of the kiln. There is no horizontal stacking, and the conical portion of the chamber remains empty. When the kiln is full, the two vents in the roof are closed and the side door is bricked up, a small hole being left and closed with a plug of clay for purposes that will be apparent later. The contents are then ignited through a small tunnel packed with combustible material which communicates with the inner chamber on the ground level and projects about 3 feet from the side of the kiln, its total length thus being about 6 feet and its diameter about 18 inches. Firing in this tunnel continues throughout the burn, which takes from 30 to 35 days and which may be slightly retarded or accelerated by exceptionally wet or dry weather. There is no means of regulating the heat, the vent holes remaining open all the time and discharging steam and volatile bye-products which, with a little ingenuity, it might be possible to condense and utilise. When, from the temperature at the bottom of the side-door, it is judged that the burn is nearly complete, a stick is inserted through the small hole in the door just above the ground level. If it chars right through, the vents and tunnel are sealed up and the kiln is left to cool off for a week, after which the side door is opened and the charcoal removed, the two vents in the roof being opened for ventilation when the kiln is half empty and there is no danger of ignition from a through draught. The work of discharging and recharging is completed, if possible, in a single day. The burners will not open the kiln unless there is enough wood for a new charge stacked in its immediate vicinity.

Conversion is, on the whole, very satisfactory, and the quality of the charcoal good. The ends of the logs that are in contact with the floor of the kiln cannot, however, be thoroughly charred without causing excessive combustion of the upper portions. They are, therefore, struck off with a mallet as the charred logs are carried out, and are set aside to be sold at a cheap rate for domestic purposes, being known as *kepala arang*. The charcoal proper is divided into two grades the better of which is formed by pieces weighing not less than 1 kati, or about 1⅓ lbs.

Measurements were made of the capacity and outturn of 10 average kilns, opportunity being taken at the same time to ascertain the average weight per cubic foot and percentage of bark. It was found that there was no appreciable difference between the specific weights of the three species used, viz: *bakau kurap*, *bakau minyak*, and *tumu*, but that there was considerable variation in the bark percentage*. For the purposes of establishing the relation between wood put in and charcoal taken out it was assumed that the three species were present in equal proportions.

The figures are summarised below. In the absence of any means of ascertaining the moisture content they cannot, of course, be taken as scientifically accurate, but as the tests were carried out under practical conditions that were in no way influenced by the investigator they may be regarded as truly indicative of the process as conducted in the field.

AVERAGE FIGURES FOR

Bakau minyak, *B. kurap*, and *Tumu*.

Weight of logs, including bark, per cubic foot ..	72 lbs.
„ „ wood, excluding bark, „ „ „ ..	77 lbs.
„ „ bark alone „ „ „ ..	55 lbs.
Percentage of bark by volume.	20%
„ „ „ by weight.	16%
Yield of charcoal fully charred.	21.8%
„ „ "*kepala arang*", half charred. ..	10.2%
Average capacity of kilns (779 c. ft.) solid	25 tons.

The outturn figures compare very favourably with the 20% which is considered a fair average for rough barked species in Europe. Were the logs to be barked before conversion, the yield of utilisable charcoal would, theoretically, be considerably higher, as the charred bark has no market value. Whether this would follow in practice is not at all certain for, as has already been stated, the Chinese burners make a point of the retention of the bark and

* See page 199.

consider it essential to a successful burn. It would be interesting to know whether, and if so, to what extent, this view is based on custom or prejudice, and whether it would not be possible to modify the process to allow of the independent utilisation of the best of the bark for tanning purposes, as described in section (*h*) of this chapter. Admittedly it is not the practice to remove the bark in other countries, but this is probably chiefly due to the expense and labour involved, which would only be justified were there a market for the bark. Here, where the value of the bark is far higher than the cost of removing it, there would appear to be some reason for believing that the matter is worth further consideration, at any rate as far as *Rhizophora mucronata* is concerned. A battery of kilns is illustrated on page 228.

(*f*) LIME BURNING.

On some parts of the coast, notably in the Dindings and Penang, deposits composed chiefly of *kerang* (cockle) shells have been thrown up by the waves in sufficient quantity to justify their conversion into lime. The usual form of kiln is a shallow structure of brick and clay, open at the top, with a bellows at the bottom. The shells are mixed with about their own volume of charcoal, dried bark, and coal (roughly in the proportion of 16: 13: 5 in the Penang kilns) and the whole mass is carefully arranged over a sub-stratum of rice straw in such a manner that chimneys of the latter project through the mixture. The straw is then lit from above and fanned to drive the heat downwards. When the whole mass is glowing the bellows are brought into action, and fresh supplies of the mixed shell and fuel are thrown in, the process being continued until the kiln is full to the top with burned lime.

The object of the straw is merely to start the burn, which is then carried on by the more slowly burning fuel that is distributed throughout the mass. Under favourable circumstances, and if the workmen show reasonable skill, the process is completed within 6 hours and the lime is free from residue.

The lime is usually slaked on the spot and is worth in this condition about 70 cents per pikul or about 1/– per cwt.

(*g*) UTILISATION FOR SUCTION GAS.

Competition from more easily handled forms of fuel, *e.g.*, coal and oil, and the increasing use of electricity, have led to investigations into the possibility of using mangrove wood or charcoal in suction-gas plant. Producer gas from mangrove charcoal has been used for some years by a dredging company working in Siam, where it is said to have proved an economical form of power. The use of charcoal is, however, not likely to become general in Malaya owing to the difficulties attendant on its manufacture and already discussed under that heading.

The idea of using the wood itself, without the necessity for previous conversion into charcoal, is not a new one, and such installations have for many years been functioning in many parts of the world, though not so far in Malaya. The largest plant of this kind is believed to be at the Lonely Mine, Southern Rhodesia, where the saving over steam is said to have been enormous, and the efficiency far greater. Until quite recently the use of wood in producer-gas plant was regarded as not entirely safe, and liable to go wrong unless under expert supervision. These initial difficulties have, however, now been overcome and, as the following excerpts from a report from one of the best known manufacturers of internal combustion engines will show, the use of mangrove wood within a reasonable distance of the swamps should (even at present prices) be an extremely profitable proposition as compared with other sources of power.

Report on Tests with Bakau Wood Supplied from Perak Forests.

"As received the wood was in the form of logs 6′ 0″ long with an average diameter of 5″. In order to make it suitable for the small producer in which it was tested it was cut down to pieces about 4½″ long and each piece afterwards split into four pieces.

The analysis of the wood as determined by our own chemists, is as follows:—

	Dried Sample.	
Ash	1.35	
Moisture	—	16.14% in laboratory.
Volatile matter	84.10	
Fixed carbon	14.55	
	100.00	

Remarks: Chloride was estimated as common salt (sodium chloride). Percentage—0.302% on dried sample. Test carried out on sawdust from cutting up of the logs. Cal. value: about 6,500 B.T.U's per lb.

The fire was lit in the producer on Tuesday afternoon about 5.0 o'clock, and the fuel allowed to burn slowly in order to form the charcoal bed ready for the test.

On the actual test the plant was started up at 12.0 o'clock noon, gas being obtained at 12.15 p.m. The suction on the main to the compressor was 2″ water gauge, and the gas was delivered by the compressor to an open burner, which, from the size of the orifice, we have determined passes about 3,000 cu. ft. of gas per hour. The plant was tested for five hours, during which time 30 buckets of fuel were used, each bucket averaging 18 lbs., weight; the total fuel consumption being 540 lbs. or 108 lbs. per hour.

Samples of gas were taken at intervals during the afternoon and the following are the results of the analysis:—

Time	2.15 p.m.	2.25 p.m.	3.20 p.m.	3.40 p.m.	4.0 p.m.
CO^2	7.2	7.5	7.5	7.0	7.2
O^2	0.6	0.5	0.5	0.6	0.5
C0	27.9	29.2	28.2	27.0	27.7
CH^4	3.5	3.9	3.2	3.5	3.3
H^2	10.6	11.4	11.8	12.0	11.6
Comb.	42.0	44.5	43.2	42.5	42.6
B.T.U's per cu. ft. nett	161.7	169.1	163.0	163.0	162.0

The high calorific value of the gas indicates that the *bakau* wood is, as we expected, one of the best classes of fuel for the production of suction gas. Taking the consumption figure of 108 lbs. per hour and dividing this into the volume of gas delivered to the burner, we obtain a figure of 28 cu. ft. of gas per lb. of fuel.

The average calorific value of the gas was 163 B.T.U's per cubic foot and multiplying this figure by the number of cubic feet per lb. gives the actual heating value of the gas obtained from one pound of fuel, viz: 4564 B.T.Us. Dividing this latter figure by the actual calorific value* of the wood we get 70% as the efficiency of the producer plant.

The calorific value of 6,500 B.T.Us. per lb. is that of the theoretically dry wood, and when giving guarantee figures the term "theoretically dry wood" must be used. Undoubtedly, the moisture content of the *bakau* wood on site will be higher than the figure we obtained, but as the moisture content will vary according to the season in which it is cut and the time it is allowed to dry, we can only give guarantees on the theoretically dry fuel. Up to 50% of moisture which is, of course, the maximum we guarantee to use, the consumption figures will increase in direct proportion to the moisture content.

This is in direct accordance with the figure on which we base our usual guarantee, and therefore the efficiency of our plant when using *bakau* wood will be as follows:—

Full load	70%
¾ „	68%
½ „	65%
¼ „	59%

Tar. About 14 lbs. of tar was extracted during the five hours run. This approximates to 2.72 of the weight of the fuel itself.

Effluent Water from Scrubber and Tar Extractor. Several samples of the scrubber and tar extractor water were taken in order to test for the presence of either chlorine or hydrochloric acid, and our chemists report that they could not find the slightest trace of either of these compounds. The chemical compounds in the water consisted mainly of acetic acid and a small amount of free ammonia, and this agrees with our analyses which we have carried out on effluent water from the average class of wood or vegetable refuse."

It is unfortunate that the possibilities of producer gas were not realised sufficiently early to permit of the installation of a power plant at Port Weld for the purpose of supplying the Taiping neighbourhood with electric current. Suggestions to this end were favourably received, but were reluctantly abandoned because they could not be fitted in with the general scheme that had already been sanctioned.

(*h*) UTILISATION FOR THE EXTRACTION OF TANNIN.

Enquiries have been made from time to time for concessions to manufacture cutch from mangrove bark but, as the grant of such concessions would apparently involve the consumption of immense quantities of mangrove fuel and the abandonment of large amounts of utilisable timber that can ill be spared, they have invariably been refused. The requirements of an up-to-date factory are, moreover, so large that there does not appear to be any single area of mangrove forest in the country that would be large enough to keep even a moderate sized one fully supplied.

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* Local independent investigators have placed the calorific value between 5,000 and 7,400 B.T.U. The above figure is, therefore, a reasonable one. Ed.

The Straits Settlements trade returns show that there has been an increase in the quantity of mangrove bark that has passed through Singapore during the past few years and that in 1926 the balance of imports over exports was rather more than 12,000 tons, or almost double the average quantity for the previous three years. This does not necessarily point to an increased output from the local tanneries but rather to a cessation in the use of Bornean cutch, which is said to be difficult to obtain and to be unable to compete with imported bark at present prices.

Practically none of the tan bark exported from Singapore is produced in the peninsula, by far the larger portion coming from Sumatra. Penang obtains its supplies chiefly from Siam. It is not easy to obtain definite details of this trade, for most of the consumers appear to purchase their supplies direct from foreign sources rather than through local dealers. This is largely due to the necessity for obtaining fresh material, bark that has dried out being regarded as worthless.

The bulk of the bark used in the Singapore tanneries appears to be from *bakau kurap* (*Rhizophora mucronata*). It arrives in Chinese junks either loose or tightly baled in sacking, and no time is lost in getting it under cover. As already stated, it must not be allowed to get dry, so if it is not required for immediate use it is stacked and kept moist by frequent waterings. A good deal of tanning material is washed out by this wetting process but, though the water that flows away is dark brown and obviously heavily charged with valuable solids, it is not considered worth while to attempt to intercept it. A course that suggests itself is a catch-pit and the use of the liquor rather than of clean water for wetting the bark. But existing methods are so crude that such refinements do not seem to have occurred to the proprietors of the tanneries, who are still content to employ the methods of the last century.

When it is required for use the bark is broken up by coolies who, sitting on the ground and steadying it with hands and feet, break it up by means of heavy hammers on small stone anvils. It is then thrown into brick or concrete vats with cold water. There is no heating of any kind. The vats are filled up with hides that have been previously prepared by scraping and treatment with lime, and these hides are taken out and turned over daily to ensure that there is efficient penetration of the liquor. Every few days the old bark is taken out of the liquor and replaced by a similar quantity of freshly pounded bark. The liquor is never changed, so that the time hides require to be treated depends to some extent on the age of the factory.

It is difficult to give reliable figures, as the vats are of different shapes and sizes and the units of measurement somewhat vague; but a vat with a capacity of about 300 cubic feet (of which the greater portion would be occupied by hides) is said to require two bullock-cart loads of pulped bark every fourth day. A fair average figure is said to be between 120 and 130 *katis* of treated and dried sole-leather for every 100 *katis* of bark put through the tanks. In other words, fresh bark can tan about 125% of its own weight of sole-leather. It is said that the value of the liquor in such a vat is between two and three hundred dollars Straits currency (about £35). The value placed by the tanners on the contents of these old vats is not easy to understand for, although it is constantly being brought up to strength by the addition of fresh bark, the proportion of soluble solids that are useless for tanning must be continually increasing as the tannin itself is absorbed by the hides.

Preference is expressed for thick bark, most of that seen obviously having been taken from large trees. It should not be brittle, and the fracture should show a clean yellow colour. Blackness and brittleness are regarded as serious defects, pieces so affected being thrown out and burned. It seems probable that the thicker bark is preferred because it retains its moisture better, not necessarily because it is definitely superior to the thin.

At the time that the tanneries were visited (early 1928) the tanners regarded the price of bark ($1.10 per *pikul*, or about 2/11 per cwt. F. O. B. Singapore) as excessive, a number of the smaller factories having had to close down not long previously. Unless the thickness of bark and, consequently, the age of the producing trees exceed what is possible under a forty year rotation there would appear to be some chance for this industry in the F.M.S., provided that it can be combined with the exploitation of firewood. The bark cannot, under existing circumstances, be described as a waste product, because it is exploited with the wood and sold with it as fuel. But as the price of mangrove firewood at the time of writing is in the neighbourhood of $25/– per 100 *pikuls* delivered on rail at Port Weld, the value of the bark for this purpose can only be assessed at 25 cents per *pikul*. As a matter of fact it should really be assessed much lower for, as already stated, an undue proportion of bark presumably detracts from the calorific value of the firewood. If, therefore, it could be removed from the trees at the time they are felled, it is not unreasonable to assume that the clean firewood would command a better price than similar grades not so treated. A fairer estimate of the present value of bark to the firewood contractor would be in the neighbourhood of 20 cents per *pikul*.

Regarded from this angle there would appear to be much in the tan-bark industry to attract the serious attention of firewood contractors and charcoal-burners in the F.M.S., more particularly those who are fortunate enough to secure felling areas with a high proportion of *Rhizophora mucronata*. This species is already well known and liked in Singapore, so there would be no prejudice against its use. Considerable savings in transport costs would be effected, and absolutely fresh bark would be guaranteed, if tanneries were to be set up in the neighbourhood of the mangrove reserves at Port Swettenham and Port Weld.

No exhaustive investigation into the percentage of bark has yet been made in the F.M.S., but the following table summarises the results of the measurement of 30 logs. It will be noticed that, with the exception of one figure (which is obviously abnormal) there is a progressive falling off as the girth increases, and that *bakau kurap* has a considerably higher proportion of bark than either of the other species examined.

Bark percentage by volume.

SPECIES.	GIRTHS.					REMARKS.
	19″–21″	22″–24″	25″–27″	28″–30″	31″–33″	
Bakau minyak ..	—	24.36	22.10	19.95	16.88	To obtain the bark percentage by weight multiply these figures by $\frac{55}{72}$ or .76.
„ kurap ..	—	23.42	29.50	26.56	24.03	
Tumu ..	18.62	16.85	15.44	14.28	10.78	

Foxworthy and Matthews (17—p. 16) give figures for Bornean swamps, the average for the *bakau* type of virgin forest being about 18% by weight, or rather less than 24% by volume.

Tannin from locally grown trees is at present manufactured on a very small scale for consumption on the spot, the tree which is specially prized being tengar (*Ceriops Candolleana*). This tree is eagerly sought after, and not infrequently illicitly cut by fishermen, who use the tan for dyeing and preserving their nets, cordage, sails, and even clothes, the life of which is said to be thereby prolonged at least three times. In Perak, where Ceriops is even less common than in Selangor, the bark of *nyireh bunga* (*Carapa obovata*) is much sought after. But even the limited demands of the fishermen are not entirely met from local forests, and there is quite a considerable import trade with Sumatra.

Though there is no lack of published analyses of mangrove bark there is no report on which a reliable estimate of the value of Malayan bark can be based, for there is wide variation in the tannin content, not only according to species, but between individuals of the same species, or even between samples taken from different positions on the same tree. These differences between apparently identical individuals are often as wide as those between dissimilar species and they may, further, be influenced considerably by the manner of harvesting, storing, and drying. It follows, therefore, that reliance on statements of the kind that have hitherto been published, based for the most part on average results from a limited and unstated number of specimens, or even from a single specimen of possibly doubtful authenticity and freshness, is likely to lead to entirely wrong conclusions.

With the object of mitigating the influence of these doubtful factors, laboratory examinations have recently been carried out by Dr. T. A. Buckley with a large number of samples, the identity, age, origin, and treatment of which are definitely known. It was originally intended to include the results of these examinations either in this chapter or in the form of an appendix, but in view of their bulk and highly specialised nature it seems preferable to publish them in the form of a separate *Record*, thus affording the investigator an opportunity to include technical details that would be out of place in this book, but which are necessary to enable a proper appreciation of the comparative merits and tendencies of the different samples and species.

Having drawn attention to the perils of attempting to generalise from the results of the examination of insufficient material, or even of giving publicity to conclusions unsupported by the details on which they are based, it would be neither wise nor courteous to attempt any definite statements in anticipation of Dr. Buckley's report. Suffice it to say that the indications are that *Rhizophora mucronata* is likely to be the most profitable species, and that *R. conjugata* is definitely inferior to it. Of the bruguieras, *B. gymnorhiza* and *B. eriopetala* give similar moderate yields somewhere between the two rhizophoras, whilst *B. caryophylloides* and *B. parviflora* are apparently worthless as tannin producers. *Carapa obovata* has given the best results as far as both quality and percentage of tannin are concerned, though this superiority is discounted by the thinness of the bark. *Ceriops Candolleana*, the much prized *tengar* bark, yields an extract that rapidly precipitates from solution, the evaporated extract being practically insoluble. This peculiarity

accounts for its efficacy as a dye and preservative for fishing nets and cordage, but is not consistent with its reputed value as a source of cutch. The use of *Carapa obovata* by fishermen for the same purposes as *tengar* is considered to be somewhat wasteful in view of the superior quality of its extract.

Generally speaking, thick barked trees have a proportionally higher content, so that an old *bakau minyak* may approach or even surpass a small *bakau kurap* in the percentage of tannin that it contains.

Of the influence of height, locality, and aspect, and of the effect of drying the bark both before and after it has been removed from the tree, I will leave Dr. Buckley to speak after he has had the opportunity of amplifying the results so far obtained.

(*i*) Thatching Material (*Atap*).

Nipah (*Nipa fruticans*) still yields an important thatching material, though it is rapidly being superseded by more permanent materials. But the demand for it is still large, even far inland, not only for the roofs and walls of temporary *kongsi* houses, but for reinforcing tailings dams and the banks of watercourses where channels and deviations are necessary in mining operations.

The fronds are cut, leaving two besides the central shoot to ensure the survival of the plant. The leaflets (in this condition known as *samir*) are stripped from the stalk and usually soaked in salt water for some days to prevent them from becoming brittle, after which they are folded over a stick of split *nibong* (known as a *mengkawan*) 4 to 6 feet long, stitched in place with a fine piece of split *rotan* or *bemban* (*Clinogyne sp.*), and dried in the sun. The thatch so prepared is known as *atap* and is made in several qualities, which vary mainly in the overlap of the leaves composing them. The best quality (*bertindeh tulang* or *pelèkat*) is only made to order; *bertemu tulang* is or was exported in considerable quantities to Deli in Sumatra; *bertemu daun* or *selèrang* is used locally; and a small variety with no overlap to speak of and known as *atap klang* is used largely for banking water courses in the tin mines. Nipah *ataps* last from 3 to 5 years according to quality, the steepness of the pitch, and the way they are laid. They are cheap, easily packed and handled, and freight charges on them are comparatively low. They are also extremely light, so that there is no need for an *atap* roofed house to have a heavy or expensive framework. One *atap* should suffice to cover about a square foot of roof. In the centres of production the prices are now from $23 to $35 per thousand.

Though the use of *ataps* for semi-permanent structures such as bungalows has been largely discontinued, there is no falling off in the demand for the cheaper kinds. *Nipah* thatch is even able to compete with *bertam* (*Eugeissona triste*) far into the interior for the latter, though plentiful, is not so durable, and to make it water tight it requires a much steeper pitch to the roof.

(*j*) POWER ALCOHOL.

Although the *nipah* palm has long been the chief source of alcohol for drinking and industrial purposes in the Philippine Islands, the plant does not occur sufficiently plentifully anywhere in British Malaya to warrant its exploitation on this account, particularly in view of the steady demand for thatch, which is generally in excess of the supply. It has, moreover, been the policy to alienate *nipah* producing areas, which are not particularly suitable for the growing of mangrove.

Considerable attention has, however, recently been given to the formation of *nipah* plantations on a large scale, and the results achieved to date are held to be sufficiently encouraging to justify the investment of considerable capital. The problem is primarily an agricultural one, and as such requires but scant mention in this *Record*; but as misunderstandings have arisen with regard to the policy of the forest department, opportunity is taken to explain the position from the forest point of view.

The forest department has no desire to place obstacles in the way of the industry, nor is there any wish to retain in forest reserves land that could be more profitably devoted to the production of a substitute for petrol imported from foreign countries. It is, however, necessary to take a firm stand against the enthusiasm of those over-optimistic applicants who imagine that *nipah* can be grown anywhere in the mangrove swamps, and that government should welcome the chance of alienating any suitably shaped area that they choose to mark out on the map, without even troubling to examine it on the spot. It is the duty of the forest department to use its influence and knowledge to prevent such enthusiasts not only from wasting the natural resources of the country, but from putting their own and other peoples' money where it would be likely to remain,—in a swamp. *Nipah* very definitely requires a considerable amount of fresh water, and though there certainly are a good many hundred acres of so-called *hutan darat* in which the palm would probably grow exceedingly well, such patches are not necessarily accessible and are probably individually too small to attract the planter.

It must be remembered that the giving up of mangrove forest may have profound effects on the local inhabitants, many of whom rely on its produce not only for their living but for the bare necessities of life. The production of thatching material from *nipah* is, apparently, not compatible with its exploitation for alcohol, removal of mature and vigorous leaves resulting in a diminution of the yield of sap.

The following facts regarding two recently formed *nipah* estates at Kuala Selangor are taken from two articles contributed to the *Agricultural Journal* by Mr. J. H. Dennett (9):

At the nursery stage *nipah* thrives in brackish water, but at an age of about two years it appears to do best when the salt content of the water and soil is very considerably reduced (compare p. 92). Observations tend to show that a high salt content of the soil when the palms are in bearing reduces the yield of sap. On one of the estates the palms were considerably retarded by the 1926 (salt water) floods. This inundation caused an increase in the salt content of the top soil from 1.09% in 1924 to 1.87% soon after the floods subsided. By fresh water flooding since then, the salt water content in some fields has been reduced to as low as 0.22% for the top soil and 0.58% for the sub-soil. The effect of this fresh water flooding on growth has been excellent, and the palms generally are now (1927) making great headway.

The water supply on both estates is controlled by water gates. If the rainfall is not sufficiently evenly distributed throughout the year, pumping must be resorted to. It is assumed that salt water will be always more or less available throughout the whole area.

The seedlings, after removal from the nursery (when they are about a span high) are planted in side pockets or recesses in drains 3 feet wide and 1 foot deep, the recesses enabling them to get enough water and to develop without blocking the drain and interfering with the flow of water along it. The usual practice is to plant 200 to the acre, and to use split bamboo guards to protect the young plants from the attacks of crabs, which eat the young shoots. They reach maturity in five or six years, but they start fruiting at 3 years or earlier, the earliest recorded being 2 years and 3 months.

The fruit takes about three months to develop. When the head is well grown, but before the darkening of the fruit sets in, the stalk is subjected to a massaging process known as *gonchang* whereby it is ocillated, at first gently, but with increasing severity until at the end of three weeks—when this treatment ceases—it is being violently shaken. The fruit head is then cut off, and the juice starts

to exude from the cut surface. This is collected in suitable receptacles and, provided the cut is opened daily, or even diurnally, by the removal of a thin section, it should continue to yield for months. As many as 26 fruiting heads in varying stages of development have been observed on a single palm.

Tapping can continue throughout the year, apparently without deleterious effect. Each spathe produces a daily average of 16.4 fluid ounces of sap. The total quantity of liquid produced is so large, and fermentation is so rapid, that it is considered advisable to devise a pipe-line system for conveying the juice with the minimum of delay from the field to the factory. Allowing for two spathes per palm in continuous tapping, 200 palms to the acre, and 340 tapping days per year, (the last figure seems a trifle optimistic) Mr. Dennett estimates an annual yield of from 12,700 to 13,940 gallons of juice, or from 1270 to 1394 gallons of 95% alcohol per acre.

Foxworthy and Matthews (17) give an account of the industry as practised on a small scale in British North Borneo, where there are very large stands of pure *nipah* swamp. Even allowing for the disadvantages of extensive exploitation as compared with the ease of transport and rapidity of collection under plantation conditions, and assuming a yield of only 250 gallons per acre per annum, these authors consider that there is every opportunity for the development of a very large industry in that country. In the Philippine Islands the cultivation of *nipah* for alcohol production has been practised on a considerable scale for many years. According to Brown and Fischer (5) more than 55% of the 13,000,000 litres of proof alcohol manufactured in the Islands comes from the *nipah* palm.

(*k*) MISCELLANEOUS USES.

Medicinal. The crushed fruit of *Acanthus* (Jeruju) is said to make a good blood purifier and dressing for boils and snake bite (Ridley). The seeds are reputed to have anthelmintic properties (23). *Avicennia* sometimes exudes a resinous substance that is used for birth-control purposes (23). The seeds are made into an ointment useful for relieving small-pox ulceration. From the fruit of *Bruguiera eriopetala* (Mata buaya) a lotion for sore eyes is made (23). A decoction of the bark of *Carapa* (Nyireh) is said to be efficacious in cases of dysentry and cholera (52). Rubbing with the fruit of *Cerbera* (Pongpong) is said to relieve rheumatism (42). The sap of this species has purgative properties and, externally applied, allays the poisonous effects of skate fish stings. The oil from the seeds is useful for the treatment of scabies (23). Obstetric (23) and haemorrhage cases are treated with an infusion of *Ceriops* (Tengar) bark, whilst on the African coast the young shoots of this genus are said to be used as a substitute for quinine (53). The pounded seed-kernel of *Cycas* is reported to cure yaws (23). Leprosy is treated in the Fiji Islands by tying the sufferer over a slow fire of the wood of *Excoecaria* (Buta-buta). The results are occasionally beneficial but often

fatal and always painful.* A plaster made from the roots of this tree, ground up with ginger, is said to reduce swellings on hands and feet, whilst a filling of the decorticated root or twig is reputed to relieve the pangs of toothache. The bark and latex have strong purgative properties. The resin (only occasionally produced) relieves cramp in the stomach if taken internally, and applied externally with the addition of a little coconut oil, is recommended for the treatment of various skin-diseases (23). From the leaves of *Hibiscus tiliaceus* (Baru) are made decoctions useful as hair-restorers, expectorants, and for the treatment of obstinate cases of retention of urine (23).

The bark of *Kandelia* (Berus-berus) forms an ingredient in a mixture given for diabetes (52). A decoction of *Lumnitzera* (Teruntum) is said to relieve thrush in infants (23). The leaves of Pluchea (Beluntas) furnish a substitute for camomile. Infusions with water are said to make an excellent mouth-wash and fever mixture. An astringent ointment is occasionally made from them (23). An infusion of the bark of *Rhizophora mucronata* (Bakau kurap) is given for haematuria (38). The fruit of *Sonneratia* (Berembang and Gedabu) is made into poultices for sprains, and the fermented juice is used to check haemorrhage (52). The heart-wood of *Thespesia* (Baru) is said by Rumphius to be invaluable in cases of pleurisy and cholera. The leaves furnish a specific for relieving headaches and are used in the treatment of scabies. An ointment made from the seeds is said to kill lice. (23).

Food and drink. The young radicles of *Bruguiera caryophylloides* and *B. eriopetala* (Berus and Mata buaya) are eaten as a vegetable in some of the less fortunate Dutch Indies, and a somewhat evil smelling condiment is made from the bark of *B. gymnorhiza* (Tumu) (23). The fruits of *B. eriopetala* and *Ceriops Candolleana* (Tengar) are chewed as a substitute for Sireh or Betel (23). Starch similar to sago can be obtained from *Cycas* (23). A light wine is said (53) to be made from the fruit of *Rhizophora mucronata* (Bakau kurap). The leaves of *Sesuvium* are esteemed as a vegetable (42). The fruits of *Sonneratia acida* (Berembang) and *S. alba* (Gedabu) are edible and not unpleasant, though somewhat sour. *Nipah* provides sugar, vinegar, and alcohol from the sap of the flower stalk, whilst the immature fruits, bottled with sugar, make a palatable sweetmeat. The cabbage of *Oncosperma* (Nibong) is much appreciated as a salad and pickle.

Oils and fats. A fat suitable for illuminating purposes and as a hair oil is extracted from the seeds of *Carapa* (Nyireh) (52), and an edible fat is said to be contained in the seeds of *Cerbera* (Pongpong).

Litter. *Acrostichum* (Piai) fern is sometimes used for bedding for cattle.

Incense wood. As its specific name implies, *Excoecaria Agallocha* (Buta-buta) occasionally furnishes a scented heartwood sought after for incense (1). Rumphius states that a scent (presumably incense) is made from the pneumatophores of *Bruguiera eriopetala*.

Cigarette wrappers, or *daun rokok*, are made from the undeveloped leaves of *Nipa*.

Fishing floats. The pneumatophores of *Sonneratia Griffithii* (Perepat) furnish a substitute for cork and are carved into floats for fishing nets.

Anchors for small boats are occasionally made from the stilt roots of *Rhizophora*.

Splitting stones. Ridley (41) says that granite can be split by pouring water over it after it has been previously heated with a fire of Carapa wood.

Fish poison is contained in the stem and roots of *Derris uliginosa*, though not, apparently, in sufficient quantity to make its exploitation remunerative. The sap of *Excoecaria* (Buta-buta) has similar properties (23).

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* *Sieman—Flora Vitiensis.*

Chapter VII.

EXPLOITATION.

The forest department realises that firewood is too costly, and that the result may be a reduced demand; but the evergreen suggestion the cure is an immediate reduction of government charges wilts on consideration of other factors governing its cost. Among them are the bad debts incurred by employers owing to the large advances demanded by an untrustworthy and impermanent labour force; the unwillingness of employers and employed to adopt less primitive and more efficient methods of felling, conversion, transport, and marketing, and to co-operate to avoid fines for bad work or illegalities; and the apparent inability of local commercial associations to help towards a solution of these difficulties. These and other questions which are discussed later will be better understood from the following account of the mangrove firewood industry.

(*a*) THE ALLOTMENT OF SUB-COUPES.

Disregarding the smaller reserves, which are worked in the manner best suited to local requirements, the rotation for mangrove has now been fixed at 40 years, and the annual coupe is calculated at one fortieth of the exploitable area. It was at first thought that a 20 year rotation would suffice, but delayed regeneration and a comparatively slow girth increment necessitate a considerably longer period, though the present figure is likely to err on the side of caution. The position is, however, fully discussed in Chapter V.

The total annual coupe is approximately 2,200 acres in Perak. It should be about half that area in Selangor, but over-cutting has been going on for so long in the latter state that undue hardship would result from too sudden a fall in the outturn. Though the demand is largely being met from thinnings the annual coupe permissible under a 40 year rotation is, therefore, still being exceeded.

When, in 1922, the railway department abandoned the use of mangrove firewood and substituted coal there was, for a time, some difficulty in disposing of the full outturn in Perak, in spite of the acute shortage of fuel in the tin fields of Kinta within 50 miles of the chief distributing centre at Port Weld. The extension of tin dredging in the Taiping district re-absorbed most of the excess within a short time, though the shortage and high price of labour that always result from prosperity in the tin and rubber industries make it increasingly difficult to market the wood at a

price that can compete with other local or even imported fuels. In 1925 and the early part of 1926, when high wages ruled and money was plentiful, the forest department came in for some particularly sharp criticism from the mining community for its failure to keep the price of firewood down in the face of the increased cost of labour and every other commodity.

In spite, however, of the use on the newer dredges of water tube boilers (which are said to be incapable of maintaining a continuous head of steam with mangrove fuel) and the consequent use of coal and ordinary firewood; and despite increasing competition from oil, electricity, and other forms of power, the position at the time of writing is satisfactory and the forests are still being worked to their full capacity. The demand undergoes periodical fluctuations which depend primarily on the price of tin, but also to a large extent on the weather and the amount of pumping that has to be done on the mines.

Exploitation is almost entirely in the hands of Chinese, though pole thinnings in Perak are usually carried out by Malays, who are less liable to disregard instructions and are content to work on daily wages and smaller profits.

The area of the sub-coupes was formerly limited only by the size of the annual coupe in each working circle, with the result that complete exploitation was quite impossible within a reasonable period and the sub-coupes were either closed with most of the exploitable trees untouched or were allowed to remain open for an unconscionable time, either alternative making it impossible to adhere to anything approaching a proper working plan. Their size has, therefore, been reduced from time to time until the average now does not exceed 75 acres.

The sale of standing timber ceased in 1916, prior to which (in Perak) all sub-coupes were sold outright by tender. This was succeeded by the royalty system, under which all wood was brought to account at fixed rates, with the addition of a small acreage premium and the obligation to supply, on demand and at a fixed price, up to a certain quantity to the railway department. Royalty was fixed at $2.38 per hundred *piculs*, or roughly 40 cents per ton, this figure corresponding approximately with the average derived from the areas sold outright in previous years.

During the war, the demand for firewood exceeded the supply, and profiteering was rampant, so in 1918 the whole Perak outturn was taken over by the forest department at rates fixed by contract, and orders were executed in rotation at prices which, whilst providing an increased profit to Government, reduced the cost of fuel very

considerably to the consumer and checked ruinous competition amongst the miners. In 1920 this business was handed over to the timber branch of the railway department, in return for a percentage of the profits, subsequently commuted to royalty at the rate of $6/- per 100 *pikuls* ($1.00 per ton) for all wood used by the railway department, and $7.50 per 100 *pikuls* ($1.25 per ton) for that sold to other consumers. In 1922 the railway administration decided to abandon firewood in favour of coal, and royalty was retained at the rate of $7.50 for everybody.

The distribution of sub-coupes up to this time had been decided by tender; first on the bids for the standing timber, then on the rates at which contractors undertook to supply part of their outturn to the railway department, and lastly on the price at which they contracted to supply their whole outturn to government. There was, therefore, no great difficulty in disposing of the more inaccessible areas, the additional expense of working which was taken into consideration when the tenderers made their offers.

When control was abolished in Perak and a fixed rate of royalty imposed on the outturn of all coupes it became difficult to dispose of any but the areas within easy reach of the railway or road, and the more distant sub-coupes (except for one or two which were conveniently placed for export purposes) were at a discount. To obviate this, the royalty on all sub-coupes was reduced to $4/- per 100 *pikuls* ($0.66 per ton), and tenders were invited for the right to work at this rate plus an additional premium. Prospective contractors were invited to view the areas and to state under sealed cover the premium that they were willing to pay. The sub-coupes went to the highest bidders (subject to their ability to work them) and there could be no complaints of unfair treatment anywhere.

But soon the consumers began to complain bitterly about the high price of firewood. The contractors were willing to bid up to any figure for a good working area, for they knew that the local miners must have the wood and would pay the price, and they were more than ready to add a little more than was necessary and to put the blame for the increase on to the forest department, into whose coffers flowed the extortionate premia that were being levied. With ever increasing labour troubles it was obviously to their advantage to squeeze the local users, who could not get wood elsewhere, and to save the trouble and risk of looking for orders further afield, at the same time posing as victims of an avaricious government. They naturally suppressed the fact that these high premia (up to $77/- per acre) were entirely the result of their anxiety to cut each other throats and of business methods of the kind that had forced the department to take over control in 1918.

Efforts to induce a more reasonable frame of mind amongst the contractors having failed, it was decided in 1925 to discontinue the tender system and to fix the premia by a departmental valuation based on the probable yield, the distance from the railway, and the facilities for extraction existing inside and outside the sub-coupes (see Appendix C). Royalty continued to be charged at \$4/- and the principle governing the determination of the premia was to achieve an average (including royalty) of \$6/- per 100 pikuls, or \$1/- per ton. In actual practice this worked out that an average area within a short distance of the railway paid the equivalent of the old rate of \$7.50, whilst the most distant sub-coupes of similar quality paid the bare basic royalty of \$4 -, the difference of \$3.50 covering the increased cost of transport. This is the system now generally in force except that the basic royalty was reduced in 1927 to \$3/- per 100 pikuls. Up to the present it has worked well, though, in the absence of competition, allocation is by no means easy to affect without complaints of favouritism.* But this is a minor difficulty, and there are obvious advantages in being able to reward the contractors according to their deserts. The system will be better understood when the methods of exploitation and transport come to be discussed.

The departmental valuation system has only recently been extended to Selangor, where the bulk of the firewood is required for domestic consumption. The premia were formerly made payable monthly, the object being to stimulate rapid exploitation and to discourage tenderers from asking for larger areas than they were able to handle conveniently. This arrangement had obvious superficial advantages, but it tended to encourage speed rather than thoroughness and to rule out the employer of the small labour force who (having but recently risen from the ranks) is often a better and more faithful overseer than the paid foreman of a large gang. Another fact that is worth bearing in mind is that the small men live from hand to mouth and are, therefore, much more anxious to avoid fines and friction with the forest department. The larger employers are not in direct touch with their coolies, whose fines are paid as a matter of routine, having been anticipated and allowed for when the tender for the sub-coupe was submitted.

* On page 1 of the *Indian Forester* for 1926 Mr. B. H. F. Barnard discusses past and present methods of disposing of mangrove coupes in the Federated Malay States. He draws attention to the difficulty of allocation without resorting to the tender system, and remarks that when all other methods fail the matter can be settled by the drawing of lots. He admits that this method is unorthodox and that it may shock the strict economist, but it appeals to the gambling instincts of the Chinese contractors. Its chief disadvantage is that it may result in the acquisition of the best sub-coupes by the least deserving contractors, or even by speculators who enter the draw merely for the purpose of privately selling their coupe to the highest bidder. Though the drawing of lots may have proved satisfactory under certain circumstances in the past there seems little doubt that its general adoption would eventually lead to greater abuses than ever.

(*b*) METHODS OF EXPLOITATION.

(*i*) Firewood.

As already stated, the extraction of firewood is, for all practical purposes, entirely in the hands of Chinese whose methods, though by no means ideal, have proved the most effective. There is nothing in the methods themselves to account for this, for they are the most primitive of their kind and rely entirely on man-power. The secret of their success lies simply in hard work. No other type of labourer will work continuously under the conditions obtaining in the swamps. The Chinese, whose conservatism is proverbial, work as their forefathers worked before them and see no reason for a change. Their conservatism, as far as hard work is concerned, keeps the industry going, but their disinclination to consider western improvements, in spite of the steady upward tendency of wages, is a bar to progress. Until there is some change in this attitude there is little chance of working our forests to the best advantage.

Sub-coupes now average about 75 acres. They are selected by the District Forest Officer, who inspects and values them and makes recommendations as regards their allocation. They were formerly put up for tender twice a year, once just after Chinese New Year and again six months later, but now they are allotted as required, at any time of the year, in the manner already described. Details are given in Appendix C.

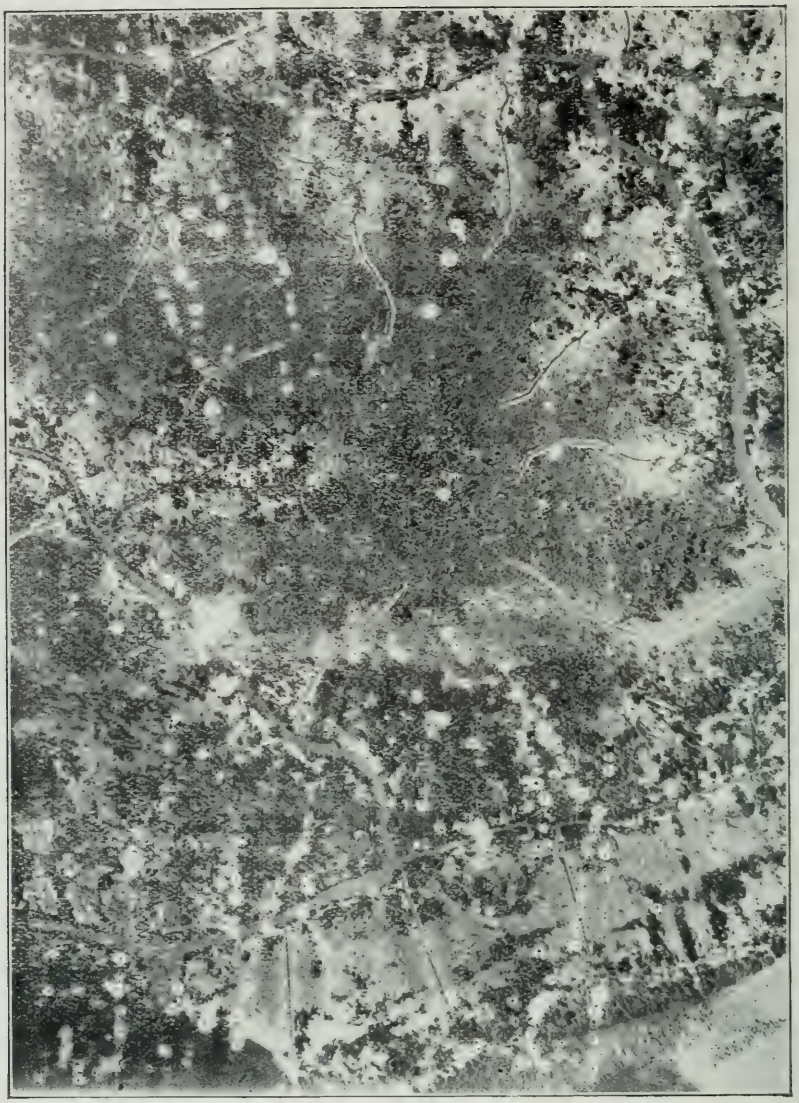
Permits, in the form reproduced in Appendix E, are signed by the Conservator of Forests. It is usual, indeed it is necessary, for work to be started immediately after the signing of the permit, but there may be reasons for delay. The sub-coupe is not, therefore, numbered until wood is actually being removed, when it is given the next consecutive number for the year. Work then continues uninterruptedly, subject to due observance of the conditions of the permit and to the monthly payment of all fees. To guard against uneven exploitation the sub-coupes are divided into lots, and work is not allowed to go on in more than two of them at a time. The selection of the lot boundaries is best decided on the spot, in consultation with the *kepala* (overseer) in order that full advantage may be taken of the natural facilities for extraction.

The permit-holder rarely exercises direct supervision in the working area, though he may visit it occasionally. It is more usual for the work to be entrusted to a head man or a *kepala* who is responsible for the erection of temporary *kongsi* or barracks, and for the distribution of working areas (*chatiam*) amongst the coolies. In the erection of the barracks there are few difficulties. Free building



64(*a*). Sub-coupes 6/26, 7/27, 12/27, & 13 to 15/28. Pulau Selat Kering, Selangor. Note the extraction canals and the optical illusion which makes the cleared (light) portions appear higher than the surrounding forest.

Photograph at 8,000 feet by Air Survey Co. September 1926.



64(*b*). A general view of 1919 workings, Pulau Che Mat Zin, Selangor. Note extraction canals connecting with rivers and still apparently intact after 7 years

Photograph at 8,000 feet by Air Survey Co. September 1926.

materials are all at hand and it is not necessary to provide anything but temporary shelter and sleeping accomodation for the twenty or so men that occupy it. Mangrove poles cut on the spot and nipah *ataps* to cover the roof and walls are all that are required, except for a few planks and cooking utensils brought along from the last *kongsi* to be vacated. Tubs must be provided to store water for drinking and cooking purposes, and suitable arrangements must be made to bring regular supplies of food. In times of drought the water supply must be augmented from distant wells or the sources of streams, an expensive business if it has to be continued for long.

To meet all these expenses it is usual to make a monthly levy on each cooly, as much as $5/- being charged where working conditions are easy. Where extraction is difficult or unduly protracted the levy may be reduced or entirely remitted. Sometimes tools are found by the contractor, or the coolies may be expected to find their own, or perhaps only their axes. There are no fixed rules. The main idea is to keep the men satisfied and to discourage them from absconding with the large advances on which they invariably insist before they will start work.

This advance system is one of the greatest obstacles to systematic exploitation. The coolies deliberately run up a debt of anything up to $100 or even more and in this way have their employer at their mercy, for if he tries to hold them responsible for breaches of the agreement or offences against the forest rules, or if he makes himself unpleasant in any other way, there is nothing to prevent them from moving on to another *kongsi* where they are almost certain to find employment. Recovery of the debt is only possible by civil action, and a summons is not only difficult to serve but of little use even if the offender can be traced. And if things get too hot for him in Perak he can find work in Selangor, and *vice versa*. Employers hesitate to carry the action too far for fear of getting a bad name with the coolies, so most of the culprits get away with the money.

Some years ago in Perak a concerted attempt was made by the contractors, who signed an undertaking not knowingly to employ an absconded cooly unless they paid his debts to his former employer and agreeing, if his services were retained, to allow the deduction of the amount of his obligation from their deposits in the forest office. But as there is seldom documentary evidence of these advances, and as the employers often disagree as to the amounts due, and as, moreover, action by the District Forest Officer without the full consent of the depositor would be quite illegal, definite settlement on these lines is seldom accomplished.

The existence of such an agreement amongst the employers did, however, help to prevent a certain amount of loss, though periodical labour shortages always lead to a recurrence of the evil. One of the larger contractors has started a bonus of $1/- per 100 *pikuls* on the outturn of any cooly who is free from debt, and is confident that this will pay him in the long run. But a tax of 17 cents per ton is a heavy price to have to pay as insurance against bad debts, and of course it is the consumer who has to pay in the end. Registration and identification of coolies by means of photographs have recently been voluntarily adopted in Perak and are said to have given good results.

The *kongsi* house having been completed at the expense of the employer, extraction can be started, but as the coolies decline to work in gangs, and may even go so far as to refuse to work even in pairs, a somewhat complicated allotment of working areas (*chatiam*) has first to be made by the *kepala*, who decides on the river frontage to be given to each cooly. They then set to work, singly, or in pairs, or very occasionally in groups up to five, to prepare their stacking and splitting platform, which must be on the bank at a spot where the transport *sampans* can come alongside at high water. Here they fell poles with which they cover the muddy ground for a space large enough for their requirements, and on it they erect rough sawing " dogs " and a rail to support the logs when they are up-ended for splitting. The platform is sometimes roughly thatched as a protection against the sun.

Felling then starts by the cutting of convenient trees in such a way that the topped trunks lie end to end and form a rough track on which the wood can be carried out. After a sufficient number have been felled, the trees not forming the track are cut into the largest portable length which is an exact multiple of the length of firewood required, and when all have been so cut they are carried to the stacking platform. When all have been brought out they are put on the " dogs " and sawn to the required length, and after this has been finished they are up-ended and split, being then stacked at the water's edge to await the transport boats. As the coolies are paid according to the actual weight of wood, they naturally try to keep it as wet as possible, and are careful not to cut more trees than can be speedily converted and taken away.

It is a peculiarity of these coolies that even when they work together they all do the same work. There are no specialists. This makes for versatility, but it means a good deal of mis-applied effort and it greatly hinders the adoption of labour-saving devices. As



65. A kongsi house, occupied by extraction coolies.



66. An extraction canal in Rhizophora forest.



67. Carrying the wood to the river bank.



68. Sawing, splitting, and stacking on the river bank.

an example of this may be instanced the writer's efforts to induce a contractor to use sledges and a slipway in an area of *berus* forest where conditions were ideal for the purpose, but where the chief objection raised to the scheme was the fact that it would need more than two coolies to work it!

The weight of the logs carried out by the coolies is very considerable, a strong man being able to shoulder up 2 *pikuls* (266 lbs.) and to walk with it along a slippery log for some considerable distance. This distance varies according to the quality of the forest. In a very good area where work is easy and the logs are not too large, and where profits are consequently high, coolies will carry the wood as far as 150 yards, but if it is poor they will not take it for anything like that distance unless they are paid extra. This makes inferior areas difficult to work at a profit, and it is often only by threats of severe penalties that the contractors can be prevented from abandoning them.

The *sampans* or boats used for the conveyance of wood from the sub-coupe to the railway sidings, or to the junks or lighters that are used for transport in the open sea, are of the usual Chinese type, capable of moving rather more than 100 *pikuls* (6 tons) and drawing about 4½ feet of water when fully laden, when they have but a few inches of freeboard and can only be navigated in the rivers. In Selangor, where there is more open water, rather a larger type of craft is used, the average capacity being in the neighbourhood of 200 *pikuls* (12 tons). These boats have sufficient freeboard to enable them to ply with reasonable safety in the open sea, and they are usually provided with sails. Fully laden they float in about 6 feet of water.

The number of natural waterways capable of taking these types of craft is rarely sufficient to enable a sub-coupe to be worked with their aid alone, and it becomes necessary to engage special coolies to deepen and extend the smaller streams and to dig canals tapping the remoter parts of the coupe. The digging of these canals is an expensive business, as much as $30/- per chain being paid in the dryer areas. They must contain at least 5 feet (7 feet in Selangor) of water at ordinary high tides. They are generally empty at low tide, when their maintenance is easy. To compensate for abnormally heavy expenditure on the construction of these canals, careful note is made of the natural waterways at the time the subcoupe is valued for premium purposes, and an abatement up to $5/– per acre is allowed if conditions are unfavourable.

The digging of canals is of comparatively recent origin and is a result of insistence on complete exploitation. It has been suggested that, by interfering with the natural drainage, they may

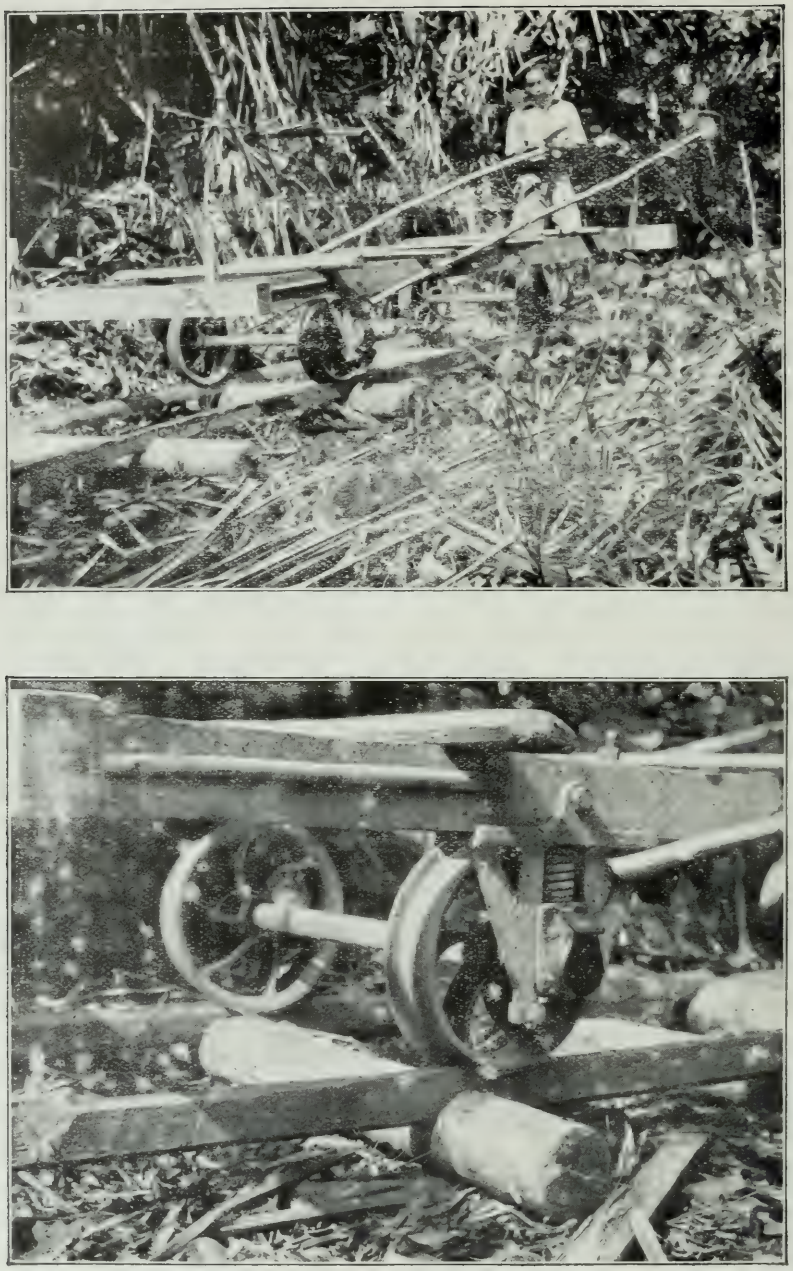
have far reaching effects on the distribution and development of the different species, and one officer has recommended that their banks should be broken through at intervals to allow the areas to flood. This is a matter that requires further investigation. It does not, however, seem likely that the interference will be either intense or permanent enough to have any serious effect on forests that have been adequately regenerated before felling.

The objections to rail transport in saline swampy ground encumbered with tangled stilt roots are obvious. None the less it is likely that herein will be found a partial solution of the problem, and a well laid track was recently in use in one of the dryer *tumu* areas in Selangor. In the Banjar *berus* forests, where the ground is firm and there are no stilt roots to impede progress, sub-coupes are allotted in the form of narrow strips. The wooden railed tramway illustrated on page 221 was in use for a number of years. Though apparently successful the experiment has not been repeated either here or elsewhere. In *lenggadai* forest at Kuala Bernam an enterprising contractor is using a tramway of which the sleepers and rails are formed of round lenggadai poles roughly morticed and nailed together. The cost of construction of such a line is insignificant, all the materials except 6″ nails and the trolley being available on the spot and utilisable as firewood after they have served their purpose. Four men can lay a track of this kind at the rate of about one chain a day. The *nibong*-railed track illustrated on page 222 is in use for the transport of stems of that palm in a semi-inland patch of mangrove in Perak. It has distinct possibilities, and its use might be extended with advantage to the adjacent firewood areas.

When the working coolies have accumulated a stock of firewood, and if the tide is high enough, the *sampans* are brought up the rivers or canals and loaded with wood by the boatmen with the coupe coolies' assistance. If the tide is not high enough and the coolies have accumulated a large stock of wood on the banks they may take a holiday for a short time, thus avoiding drying out of the wood and congestion at the stacks. During the period of inferior high tides it is not unusual to find the sub-coupes practically deserted, even the *kongsi* house being more or less empty. It must not be thought from this that the coolies work short hours or have an easy time. They make up for it in between, and if *sampans* are available and a special effort is required (particularly towards Chinese New Year) they may be seen working by torch light on the river banks, splitting and stacking the wood they have felled and carried during the day. Similarly, the opium smokers are unwilling to start work before 8 a.m. but they work until sun-down.



68(*a*). Extraction tramway with sawn wooden rails in BERUS forest. Note method of attachment to sleepers. Banjar Reserve, Selangor.



68(*b*). Extraction tramway, Pasir Hitam, Perak. Rails and sleepers of NIBONG (*Oncosperma*). Note method of attachment, and that no metal is used on the line.

The quantity of firewood that a cooly can deliver in a month varies, of course, with the amount of sawing and splitting that is required, with the quantity and quality of the trees available, and with the man's own powers of endurance. "Dredge" billets 5 feet long and up to 25 *katis* (33 lbs.) in weight need the minimum of conversion and are paid for at an average rate of $8 - per 100 *pikuls*. "Engine" billets are 2½ feet long, have an approximate weight of 10 *katis* (13 lbs.), and are paid for at an average of $10/-. "Launch" billets are 24 inches long, and are worth $12/- per 100 *pikuls*. Smaller sizes are cut to order only and are paid for at special rates.

Taking dredge and engine billets in equal proportions as the standard, an experienced cooly under average conditions can deliver 500 *pikuls* (about 30 tons) of wood per month, and thereby earn about $45. The mean yield per acre for productive areas is in the neighbourhood of 72 tons. A good cooly should be able, therefore, to work out an acre in a little over two months, and a labour force of 20 men should be capable of exploiting 100 acres in about a year. Permits are usually made out for 12 months but, in the past, extensions have usually been necessary as it has not been possible to keep the labour forces up to full strength.

The advantages and disadvantages of the monthly premium system until recently practiced in Selangor have already been mentioned. The alternative method of imposing a minimum monthly royalty is discussed on page 232.

(*ii*) Timber.

Practically all timber that is taken from the mangrove reserves is in the shape of poles. The chief consumers are the fishermen, who use large quantities for their fish-traps and houses. These need frequent renewals, the life of a pole exposed at all times to the elements and to the attacks of marine borers being a matter of months or weeks rather than years.

Properly controlled, the extraction of fishing stakes is eminently desirable in that it provides an outlet for material that would otherwise be wasted in the struggle for existence. Left to themselves, the fishermen naturally take the line of least resistance, and cut their poles from the nearest forest, irrespective of its silvicultural requirements. Consequently, the forests in the neighbourhood of the *bagans* have, in the past, been characterised by large blanks and the absence of anything but crooked stems that were useless to the fishermen. Attempts to regulate these cuttings have always been resented and when in 1923 it was ruled that even the collection of royalty was

an unfair burden to these people, their ideas as to the sanctity of the forests and the authority of the forest department underwent a decided change for the worse. They are, for the most part, a lawless crowd, few of them can speak Malay, and they are apt to regard all kinds of rules as an unwarrantable interference with the liberty of the individual. It is satisfactory to be able to record, however, that there has recently been a great improvement. It has even been possible to induce the Perak fishermen to take their poles in the form of thinnings and to leave them in the forest until they have been inspected and hammer-marked by a forest officer.

The commercial exploitation of poles under permit is limited to responsible contractors, who market them in the towns, where they are chiefly used for scaffolding and piling. Malays are often employed on this work in Perak, but in Selangor, where the demand is greater, Chinese are usually employed in converting a large proportion of such poles into firewood. An experiment is now being made in the latter state in the departmental cutting of poles, which are to be sold *in situ*.

The great difficulty is, of course, to induce anyone to exploit the less accessible parts of the coupe. The outturn from thinnings is much too small to justify the construction of extraction canals, so that the tendency is to limit cuttings to the immediate neighbourhood of existing streams. Long poles are difficult to handle in closed forest, but the system of charging royalty at a fixed rate per pole has not done much to encourage the taking of shorter lengths. In Selangor, where the supply of firewood is rarely equal to the demand, such short pieces are usually converted into firewood and paid for as such; in Perak they were invariably left to rot until the introduction of a system, whereby royalty is charged at running foot rates, enabled them to be removed on rather more advantageous terms.

(*iii*) Minor Produce.

Bark for tanning purposes is worked on monthly permits and confined almost entirely to *tengar* (*Ceriops Candolleana*) in Selangor, and *nyireh bunga* (*Carapa obovata*) in Perak. Exploitation of the former is limited to trees above 18 inches in girth, whilst the latter is taken practically without restrictions as regards size. Specimens of the forms in use will be found in Appendix E.

The chief dangers attendant on these operations are the felling of undersized trees and the possibility that the bark permit may be used as a cloak to illicit firewood extraction. With regard to the former it is not practicable to limit the collectors to areas that

can be readily supervised, and unless the offenders are caught in the act they are difficult to trace. The latter form of offence is easier to deal with, for scattered exploitation of firewood is scarcely likely to be economical, whilst barked wood would be likely to attract notice if moved about in quantity.

The possibilities of a local trade in tan-bark have already been discussed and need no further elaboration here. The same remarks apply to other minor products, which are dealt with at some length in Chapter VI, and the control of which is not subject to any special regulations requiring mention in this section.

(*c*) TRANSPORT.

The *sampans* used for conveyance of firewood within the sub-coupes, and to the road and railway by inland waterways, have already been discussed in some detail on page 219. In Perak they are rowed by a single oarsman, standing at the stern and facing forward in the usual Chinese fashion. They are not provided with sails and can only travel at slack water or with the tide, and as they have but a few inches of freeboard they cannot take short cuts by the open sea. The larger *sampans* in Selangor can stand a little more weather but, even under sail, can rarely move against the tide.

Progress is, therefore, extremely slow. When the flow of the tide ceases to favour them the boatman ties up, eats his food, smokes his pipe, and sleeps until the tide turns, when he continues his course until he is held up again. The most distant coupes in the Matang district are about four "tides" from the railway at Port Weld. It does not follow that this means 48 hours, for the channels are very tortuous and, as they connect large bodies of water, a boatman who knows them is often able to go up one on the flow and continue down another on the ebb, thus profiting by both the ebb and the flow.

The Perak boats are usually the property of the contractors, and most of them carry a little over six tons of wood. The boatmen are paid according to the number of "tides" that are necessary to bring a full load to the railway, the average being about $1.50 per tide. Transport from the most distant areas may, therefore, cost anything up to $6.00 per load, or about $1.00 per ton.

On arrival at the railway the boats are tied up opposite the stacking space reserved for that particular sub-coupe. Unloading is done by the boatman with the help of a permanent gang on monthly wages and under the supervision of a clerk, who checks the quantity delivered and furnishes a return on the basis of which

the felling and conversion coolies are paid. These same coolies stack the wood by the side of the track and load it into the trucks as soon as they are available. The boatman loses no time in returning for another load, for most of the felling areas are only approachable during the two days preceding and following the spring tides, a total of perhaps ten days in the month during which a cargo can be obtained.

The stacking spaces are allotted to the licensees by the railway department, and charged for at a monthly rate of 1 cent per square foot. This is a very unsatisfactory feature, resulting in constant squabbling, for the contractors say that most of the spaces have been reclaimed by them from otherwise worthless land and have been consolidated by a solid layer of firewood billets, pressed into the mud by the weight of the wood above. They also feel that the cost of temporary accommodation of the wood should be included in the freight, particularly when, as frequently happens, the fuel has to be stacked to an inordinate height because of shortage of trucks during high tides when the transport sampans are arriving in large numbers. (See illustration page 227).

Mangrove firewood is included in class 19 for freight purposes, being charged for as in the table below. Freight is payable on actual weights, with a minimum of 75% of the carrying capacity of the truck. Though trucks cannot be loaded to their maximum capacity by weight, they can take more than 75%, so that the minimum charge is justified and should encourage good loading. Loading and unloading must be done by the consignor and consignee respectively.

Starting with a minimum of 3.20 cents per *pikul** for the first mile the freight rises by two tenths of a cent for successive miles up to 50, the rate for which is thus 13.00 cents. Between the 51st and 100th miles the additional rate is one tenth of a cent per mile; between the 101st and 150th miles six hundredths of a cent; and between 151st and 200th miles two hundredths of a cent. It is doubtful whether it would ever pay to haul firewood for more than 100 miles, so the comparatively low rates for the longer distances have little practical significance.

The freight on one ton of firewood is therefore:—

For	1 mile	@	3.20	cents	per	pikul	= $0.54	= s. 0/9
,,	25 miles	@	8.00	,,	,,	,,	= 1.34	= ,, 3/1½
,,	50 ,,	@	13.00	,,	,,	,,	= 2.18	= ,, 5/1
,,	75 ,,	@	15.50	,,	,,	,,	= 2.60	= ,, 6/1¾
,,	100 ,,	@	18.00	,,	,,	,,	= 3.02	= ,, 7/0½

* 16.8 pikuls=1 ton; 1 pikul=133 lbs.
$1=2/4; 3.20 cents=9d.



69. A typical sampan in Perak. This boat carries a little more than 6 tons (100 pikuls). The Selangor boats are larger and can take double this amount.



70. A firewood dump 35 feet high at Port Swettenham.



71. Loading firewood into trucks, Port Weld.



72. A battery of charcoal kilns, ~~Pergi~~ Nanas, Selangor.
Perigi

When wood is exported or removed by an agency other than the railway it is necessary for the *sampans* that remove it from the coupes to be registered at the forest office, in order that the forest guard in charge of the coupe may issue removal passes based on their carrying capacity. This is not necessary in the case of wood destined to be transported by rail, as this is brought to account on the basis of the weigh-bridge returns, and it is immaterial how it is transported between the working area and the railway siding. It is, however, usual in Perak to issue consignment notes even where removal passes are not required. These state the origin and destination of each boat-load of wood and serve to prevent unauthorised removal, to facilitate control in transit, and to discourage the mixing of the outturn from different sub-coupes worked by the same licensee.

The carrying capacity of the registered boats is measured by weighing the wood that is put in until the boat is loaded well down, when a "Plimsoll" mark is cut into the planks on either side by the forest officer who superintends the weighing. Though reasonably accurate if carefully carried out, this method of measurement is open to abuses which are difficult to check. Removal of the plug in the bottom of the boat for a few seconds is obviously to the advantage of the cutting coolies (who are paid by *sampan* weights) and of the boatman, who can bail out the water as soon as he gets round the corner and go on his way with a light load until he nears his destination and has to let it in again. That royalty is paid on the water as well as the wood disadvantages nobody but the man who has to pay it, and he is not usually there to check the weights. And even when the loads can be verified with the railway weights the loss by evaporation is heavy enough to be made the excuse for any discrepancies. A truck loaded with wet wood and left to stand in the open for a few hours will lose anything up to 10% of its weight, so it is not surprising that the contractors often prefer to use closed wagons which, though more difficult to load, retain the moisture and save them from accusations of short measure. Thefts in transit are not infrequent when open trucks are used for long distance traffic.

It might be thought that the use of lighters and tugs would prove more economical than the employment of the old fashioned one-man *sampans*, but this has not proved to be the case so far, although it was tried by an association that until recently catered for some of the mines in the neighbourhood of Taiping. The reason for this is not far to seek, for the lighters could not enter the extraction canals, and the wood had to be taken in the usual

type of *sampan* to where they lay at anchor in the main river. Any economy that was effected in the actual haulage was more than lost in the extra handling that the wood received in being loaded into the lighters and unloaded again at Port Weld, where their large size and height made them more awkward to deal with than the smaller craft.

It is not suggested that these obstacles are insuperable. Many solutions suggest themselves, such as the use of smaller lighters that could enter the canals and yet be sufficiently sea-worthy to stand the strain and wash of towing; or that might be locked together to form a composite craft that could be split up into its component units whenever necessary; or the adoption of the sectional type of truck used on the American (and possibly the English) railways, whereby the sections are removable and might be taken out of the coupes, loaded there, and lifted back on to the truck by means of a travelling crane. That something on these lines will have to be attempted in the near future is certain. That it has not been done in the past is due to the conservatism of the Chinese, who have the whole industry in their hands and who have now neither the capital nor the inclination to adopt more modern methods, though they realise well enough that the old days of cheap labour are rapidly passing.

(*d*) DEPARTMENTAL SUPERVISION.

Each sub-coupe is regularly inspected by a forest officer who gives such orders as may be necessary for thorough exploitation and protection. The district forest officer uses a launch, on which he may live for several days at a stretch. The rangers are provided with small motor boats on which they can sleep at some sacrifice of comfort if they cannot reach more comfortable quarters in time. The work is generally popular, in spite of mud and mosquitoes, for it is not only healthy, but it approaches more nearly to the standard of European forestry than is possible in the inland forests in Malaya.

On the more remote areas it is usual to erect temporary quarters in which a forest guard lives and supervises the work in two or three sub-coupes which are, for this reason, grouped together. The responsible guards are provided with boats to enable them to get from one area to another and to return to their headquarters to buy provisions. This they usually do during low tides when work in the coupes is slack and the removal of wood impossible.

The duties of the guard are to enforce the provisions of the permit and to report any matters which he is not authorised to deal with direct. He must visit the *kongsi* houses regularly, inspect

the working board on which the names of the coolies are displayed, and must see that all are provided with sub-permits. He is provided by his ranger with a map of the sub-coupes for which he is responsible, showing such rivers and streams as have been surveyed, and the division into lots, not more than two of which may be worked simultaneously without special sanction. He is expected to keep this map up to date by sketching in any unsurveyed streams and extraction canals, by indicating the positions of stacking platforms, and by marking the progress of exploitation by shading or any other convenient method. Where a minimum girth limit is imposed he must mark and initial the stumps of all trees that have been illegally felled, and furnish a monthly statement giving details of trees affected and the number of the offending working area. He must not allow any *chatiam* to be abandoned until he is satisfied that all reasonably exploitable wood above 8″ in girth has been removed from it, and he may forbid, pending confirmation from headquarters, the opening up of any fresh area if work elsewhere has not been satisfactory. Where wood is exported he must know the capacity of all *sampans* used in the loading of larger vessels, and must issue passes for all wood so removed. As this is the only check on wood that is not transported by railway it is essential that he should be on the spot at all times when the *sampans* are working.

As mentioned in the chapter on silviculture, efforts are now being made to assist natural regeneration by the treatment of areas on their merits, rather than by the imposition of arbitrary rules. This entails closer supervision by the guards in charge, who are expected to keep pace with fellings and to mark for retention such trees as they consider necessary to seed up the areas under exploitation, having regard to the conditions existing on and above the ground. In this way it should be possible to enforce more systematic exploitation and to prevent the objectionable practice of removing only the better wood and leaving the rest to be cleared up later under protest by coolies paid at higher rates, or abandoned if its removal is not enforced by the officer in charge.

In wet, easily worked areas, stocked with moderate sized trees, supervision is simple, because the coolies will take everything without question. But where conditions are not easy, particularly where there are large *tumu* or a high percentage of *ngirch*, the lot of the supervising guard is not an enviable one, and it is on his powers of persuasion or coercion that the thoroughness of exploitation chiefly depends. If once he allows himself to be put off with promises to return to the area later on it is quite likely that the

offending coolies will abscond or refuse to return at any price, and even if the place is eventually cleared up the chances of natural regeneration are not improved by the delay and the double operation.

Very close supervision by the guards and frequent inspections by foresters and rangers are of supreme importance. The district forest officer cannot hope to get round very often to the forty odd sub-coupes that are being simultaneously exploited and when he finally arrives he can only form a general impression of the cleanliness or otherwise of operations, even the best of which are always screened by masses of slash through which it is impossible to make rapid progress.

Breaches of agreement or unsatisfactory work on the part of the permit holder are punished by fines which, it is feared, often have no deterrent effect because the real culprits cannot be made to accept responsibility. But it is not easy to devise other safeguards. The present system of allotment enables the department to refuse to grant areas to unsatisfactory contractors, but this is an extreme measure and is only resorted to when all other means have been tried. Cancellation of permits for delayed work is a severe enough punishment for the holder, but as it is rarely possible to induce others to take up such uncompleted sub-coupes the usual result is to upset the working plan by leaving unexploited patches that cannot stand another rotation. For this reason permits are usually renewed for a further period after they have expired.

The form of permit now in use prescribes a minimum monthly royalty and empowers the deputy conservator to demand the difference if, in any two consecutive months, the books show a deficit. In this way it is possible to apply pressure at the right moment and to discourage the contractor's practice of applying for larger areas than they can work with the labour forces at their disposal.

(*e*) THE NEED FOR REORGANISATION.

It is admitted that the present price of firewood is too high, and at times the government, not through any extortionate demand, has no doubt reaped more than its fair share of the profits. The general policy is to levy a 10% *ad valorem* royalty on forest produce from state land; but double this is not considered excessive from reserved forests on which the forest department spends much time and money. As explained already, the surcharge has for some time been paid in the form of a premium levied in addition to the basic royalty.

It would seem at first sight that no fairer way could be evolved of assessing the premium than to put each of the felling areas up to tender; but in Perak the demand for the produce was so certain, the keeness to secure felling areas so great, and the bids in consequence so ridiculously high, that in 1925 the system for calling for tenders had to be abandoned and the premia stablised by departmental valuation. (The same system is now being followed in Selangor). The miners, however, still complained, argued that the levy of a premium was illegal, and one even gave publicity to an entirely false statement that the departmental estimates of yield on which the valuations were based were almost invariably excessive. The question was carefully reconsidered, and once again the government contributed towards the lowering of prices by reducing the basic royalty by 25%. The effect on the revenue by the stabilisation of premia can be judged from the figures on page 168; the reduction of royalty cost government in 1927 no less than $40,000.

It is very doubtful whether this sacrifice of revenue has benefited the consumer at all; it is even doubtful whether the lessees of the felling areas have profited appreciably. In all probability inefficiency has been more firmly established.

Wood is a satisfactory fuel only if it is cheap, and substitutes will be sought as soon as it becomes too dear. It must, however, be remembered that there has never been any difficulty in disposing of the supply; that it is at present being exploited at a rather low girth; that the mangrove forests of Siam, and even of Kedah, are said to be getting depleted; and that in all probability there will before long be new or enlarged markets, including Penang and possibly Singapore or even Hongkong, even if the miner takes permanently to some other fuel. The use of mangrove for producer-gas plants has already been favourably reported on.

It seems reasonable, therefore, to suggest that, before further revenue is sacrificed, the industry should make some attempt to help and to organise itself on more up to date lines. The contractors should make a determined effort to break away from the iniquitous advance system and seem to need not only facilities for the recovery of bad debts less ponderous than the machinery of the civil courts, but some measure of protection against defaulting coolies commensurate with the safeguards provided by the labour code for the cooly against the defaulting employer. Though the idea of daily wages is repugnant to the average Chinese cooly there must, surely, be some way of breaking down the absurdly individualistic attitude which prevents men from working together in

sufficient numbers to achieve greater efficiency and precludes the introduction of labour saving devices. Except for the digging of extraction canals which followed the enforcement of more thorough exploitation, no serious attempt has been made during the past 10 or 12 years to improve the handling facilities either in the jungle or at the wharf, or to utilise the stacking spaces to the best advantage. The lack of co-ordination between producer and consumer (particularly where the smaller miners are concerned) leads to constant arguments and delay in settlement, with the common result that the contractors have to be given extensions of time to enable them to waste yet another day in trying to raise the wherewithal to pay their monthly royalty. Complaints of the insufficiency of rolling stock on the railway are often justly met with the reply that the shortage is due to the failure of consignees to unload their wood at the other end, or to the impossibility of reserving trucks in sufficient numbers to deal without delay with peak demands. During the war there was for a short time a railway transport pool, but this was abandoned when the use of coal on the railway released a temporarily adequate supply of firewood trucks. Congestion at wayside station yards through non-removal of wood arriving by train results not only in further delay but in the aggravation of theft, which is said sometimes to assume serious proportions even whilst the wood is still in the trucks.

The above are but a few of the causes of high prices, applying in greater or less degree according to circumstances. Put briefly, the whole industry is being run on hopelessly inefficient lines, and as long as it remains in the hands of small men living from hand to mouth, or of larger men entirely lacking in imagination or enterprise, it is incapable of permanent improvement.

The theoretical remedy is, of course, reorganisation on a scale which will justify the expenditure of considerable capital on improved methods of extraction, handling, and transport. This could be achieved in three ways, *viz*:—

(*a*) The fusion of interests of the existing licensees.

(*b*) The formation of a company to take over all transport and marketing operations.

(*c*) Government purchase and control, starting with transport and marketing problems, and ultimately extending to the work in the forest.

The first is believed to be impracticable. Many round-table conferences have been held with the licensees, but the majority of them are too deeply set in their present rut even to think of getting

out of it, and are too firmly in the hands of their coolies to be able to introduce any new ideas.

The second has already been tried on a small scale by an association formed by some of the dredging companies in the neighbourhood of Taiping, which provided tugs and lighters for the transport of the wood from the sub-coupes to its own siding and which undertook the distribution of fuel amongst its members. This venture did not strike at the real root of the evil, for the work was still too much in the hands of the original contractors, who were willing enough to profit by the transport facilities provided, but who professed to be unable to deliver the wood on board the lighters at a price very much below what they would have charged for it loaded into trucks on the railway siding many miles away. The overhead charges were therefore, out of proportion to the scope of the undertaking, which did not succeed in lowering prices, though it contrived to a certain extent, to maintain regular supplies.

Government control of the whole output, starting in the manner adopted between 1918 and 1920, and ultimately extending to the actual work in the forest seems to offer the best solution to the problem. The first step would be to warn licensees not to look for any fresh contracts, and to enter into agreements with them to supply firewood free of all government charges delivered on rail. They would be paid on the actual weighbridge weights, on which basis the fuel would also be sold by the controller to the consumers, the present revenue from royalty and premium being replaced by a reasonable profit on sales. Even if it were not carried beyond this stage the system would eliminate several of the present evils, *e.g.*, the congestion and disorganisation of work that ensue between the termination of one contract and the commencement of another; the difficulty of obtaining orders and of exacting payment for fuel supplied; the impossibility of making the best use of stacking spaces; and the inevitable disputes that arise whenever the supply of trucks is not sufficient to meet the immediate demand.

In an organisation of this kind the forest department would have the experience of former years to guide it, and the knowledge that the results then were directly beneficial not only to producer and consumer, but to government itself. It is not recommended, however, that re-organisation should stop here. Having established connections and built up the business on a sound foundation it would be possible to devote some of the profits to improving the purely mechanical side of the industry, starting with transport problems and finishing with the actual felling and conversion in the forest.

One respect in which conditions now compare unfavourably with those obtaining during previous control is that the railway, which then consumed about half the total outturn, has since abandoned the use of firewood. The existence of a certain and regular market for such a large proportion of the crop made control far easier than it would have been had the market been subject to violent fluctuations. It is felt, however, that the demand for wood will become sufficiently stable if its price is reduced to a figure that will make it unquestionably more economical and reliable than imported fuels, and if the controller receives the requisite assistance from the various chambers of mines and commerce.

It would be out of place in a record of this kind to attempt to discuss the ethics of government trading. These suggestions are merely put forward in the belief that they would provide a solution to a problem of increasing urgency. It might, however, be mentioned that forestry is an industry that, by its importance to the state, the slowness of its returns, and the possibility of its abuse, can rarely be entrusted to private enterprise. Since responsibility for maintenance of the forest capital is vested in the forest department, it is the duty of that body to administer it to the best advantage. In countries where forestry has reached the highest stage of development, departmental operations continue uninterruptedly from the sowing of the seed to the sale of the felled trees, and may even extend to the milling and sale of sawn timber.

In suggesting, therefore, that the remedy for the present unsatisfactory state of the mangrove industry lies in increased government intervention, the writer is not proposing a temporary palliative, but is striving towards an accepted ideal.

BIBLIOGRAPHY.

Reference has been made to the following works. The list does not pretend to form a complete bibliography of mangrove literature and is given here primarily for purposes of acknowledgment.

1. Becking, J.H., den Berger, L.G., and Mindersma, H.W. Vloed—of Mangrovebosschen in Ned. Indie. "*Tectona*" 1922, XV. pp. 561/611.
2. Boswell, A.B.S. F.M.S. Forest Conference Proceedings, 1926.
3. Boulger, G.S. Wood. London, 1908. Edward Arnold.
4. Brandis, Sir D.B. Indian Trees. London, 1911. Constable and Co.
5. Brown, N.C. Forest Products—Their Manufacture and Use. New York, 1919. John Wiley.
6. Brown, W.H. and Fischer, A.F. Philippine Mangrove Swamps. Philippine Bureau of Forestry, Bulletin No. 22. Vol. I Manila, 1920. Bureau of Printing.
7. Campbell, D.H. An Outline of Plant Geography. New York, 1926. The Macmillan Co.
8. Cunningham, J.T. The Preservation of Fishing Nets. London, 1902. Adam and Charles Black.
9. Dennett, J.H. Nipah Palm. "*Malayan Agricultural Journal*" 1927. Vol. XV. pp. 422/445.
10. Dudgeon, G.C. Agricultural and Forest Products of British West Africa. London, 1922. John Murray.
11. Farrington, Sir H.A. (Bart.). Third Working Plan for the Sundarbans Division. Calcutta, 1906. Bengal Secretariat Press.
12. Foxworthy, F.W. (*i*) Timbers of British North Borneo. (*ii*) Minor Forest Products and Jungle Produce. B.N.B. Department of Forestry. Bulletin No. 1. Sandakan, 1916. Govt. Printing Office.
13. Foxworthy, F.W. Distribution and Utilisation of the Mangrove Swamps of Malaya. *Ann. Jard. Bot. Buitenzorg*, 2e. ser. Supplement III.

14. Foxworthy, F.W. Commercial Woods of the Malay Peninsula. *Malayan Forest Record No. 1*, K. Lumpur, 1920. Forest Dept. F.M.S.
15. Foxworthy, F.W. Indo Malayan Woods. *Philippine Journal of Science*, Vol. IV. No. 4. Manila, 1909. Bureau of Printing.
16. Foxworthy, F.W. Report on the Mangrove Swamps of the Sibuguey Bay Region of Mindanao. August. 1912. (Not published).
17. Foxworthy, F.W. and Matthews, D.M. Mangrove and Nipah Swamps of British North Borneo. Department of Forestry B.N.B. Bulletin No. 3. 1917, Sandakan Government Press.
18. Gamble, J.S. A Manual of Indian Timbers. Reprint of second edition. London, 1922. Sampson, Low, Marston & Co.
19. Godfrey, F.P. F.M.S. Forest Conference Proceedings, 1926.
20. Goebel. Pflanzenbiologische Schilderungen, Marburg 1889/93.
21. Guppy, H.B. Observations of a Naturalist in the Pacific between 1896 and 1899. Volume II. London, 1906. Macmillan and Co.
22. Haberlandt, G. Eine Botanische Tropenreise. Leipzig, 1910. Wilh. Engelmann.
23. Heyne, K. De Nuttige Planten van Nederlandsch Indie. Second edition. Buitenzorg, 1927.
24. Hill, H.C. Report on Forest Administration in the F.M.S. Kuala Lumpur, 1900. Selangor Government Printing Office.
25. Hooker, Sir J.D. Flora of British India. London, 1872/97.
26. Kerner V. Marilaun, A. The Natural History of Plants. Translated by F.W. Oliver. London, 1894. Blackie and Son.
27. King, G. and Gamble, J.S. Materials for a Flora of the Malay Peninsula. *Journal of the Asiatic Society of Bengal*, 1889/1915.
28. Kurz, S. Forest Flora of British Burma. Calcutta, 1887. Government Printing Office.
29. Kurz, S. Preliminary report on the forest and other vegetation of Pegu. Calcutta, 1875. Baptist Mission Press.
30. Lushington, A.W. Nature and Uses of Madras Timbers. Vespery (Madras), 1919. S.P.C.K. Press.
31. Mead, J.P. The Mangrove Forests of the West Coast of the Federated Malay States. Kuala Lumpur, 1912. Government Printing Office.
32. Mead, J.P. Report on the working of the mangrove reserves from 1914 to 1923. (Not published).

33. Mead, J.P. The Need for Revision of the Existing Working Plans in the F.M.S. Mangrove. Forest Conference Proceedings, 1915.
34. Merritt, M.L. The Forests of Mindoro. Philippine Bureau of Forestry, Bulletin No. 8. Manila, 1908. Bureau of Printing.
35. Moodie, A.W. Working Plan for the Delta Forest Division. Maymyo, 1924. Superintendent of Government Printing, Burma.
36. Oliver, D. First Book of Indian Botany. London, 1869. Macmillan and Co.
37. Parker, The Genus Sonneratia. "*Indian Forester*" 1925, Volume LI. p. 505.
38. Pearson, R.S. Commercial Guide to the Forest Economic Products of India. Calcutta, 1912. Superintendent of Government Printing.
39. Prain, Sir D. Flora of the Sundribuns. *Records of the Botanical Survey of India.* Vol. II. No. 4. Calcutta, 1903. Central Printing Office.
40. *Record*,The. Organ of the Board of Commercial Development, issued by Ministry of Commerce, Siam. Jan. 1925. pp. 145/149.
41. Ridley, H.N. The Timbers of the Malay Peninsula. "*Agricultural Bulletin of S.S. & F.M.S.*". 1901, Vol. I. Nos. 1/8.
42. Ridley, H.N. Flora of the Malay Peninsula. London, 1922/25. L. Reeve and Co.
43. Rodger, A. Forest Products of Burma. Rangoon, 1921. Superintendent of Government Printing, Burma.
44. Rogers, C.G. Note on a tour of inspection in the South Tenasserim forest division. Rangoon, 1919. Superintendent of Government Printing, Burma.
45. Sanger-Davies, A.E. Working of Matang Mangrove Reserves 1914/23, (Not published). Working plan for Matang Mangrove 1924 (not published).
46. Schimper, A.F.W. Plant Geography. Translated by W. R. Fisher. Oxford, 1903. Clarendon Press.
47. Schimper, A.F.W. Die indo-malayische Strandflora. Jena, 1891. Gustav Fischer.
48. Skene. M. Biology of Flowering Plants. London, 1924. Sedgwick and Jackson).
49. Tansley, A.G. and Chipp. T.F. Aims and Methods in the Study of Vegetation. London, 1926. Crown Agents for the Colonies.

50. Troup, R.S. The Silviculture of Indian Trees. Oxford, 1921. Clarendon Press.

51. Warming, E. Oecology of Plants. Translated by Groom and Balfour. Oxford, 1909. Clarendon Press.

52. Watt, Sir G. Dictionary of the Economic Products of India. Calcutta, 1889/96. Superintendent of Government Printing.

53. Watt, Sir G. The Commercial Products of India. London, 1910. John Murray.

54. Whitford, H.N. Forests of the Philippines. Philippine Bureau of Forestry, Bulletin No. 10. Manila, 1911. Bureau of Printing.

55. V. Wiesner, J. Die Rohstoffe des Pflanzenreiches. Leipzig. 1914/1918. Wilh. Egelmann.

APPENDIX A.

Particulars of Mangrove Areas in the Malay Peninsula.

State or Settlement.	Name of Reserve.	Area in Acres. Reserved.	Unreserved (Approximate).
Federated Malay States.			
Perak ..	Kurau ..	5,274	
	Matang ..	94,618	
	Rungkup ..	10,081	
	Total ..	109,973	1,500
Selangor ..	Banjar ..	9,645	
	Bernam ..	4,654	
	P. Padina ..	4,000	
	Kapar ..	14,468	
	Klang Island	21,817	
	Pulau Lumut.	11,290	
	Telok Gedong.	6,182	
	Pulau Tengar.	1,335	
	Jugra ..	8,626	
	Sepang Kechil.	330	
	Total ..	82,347	4,500
Negri Sembilan.	Sepang ..	1,651	
	Lukut ..	1,959	
	Linggi ..	1,290	
	Total ..	4,900	250
Pahang ..	Baloh ..	248	
	Kuantan ..	1,424	
	Rumpin ..	393	
	Pontian ..	468	
	Pulau Lang ..	50	
	Bebar ..		1,000
	Cherating ..		250
	Total ..	2,592	1,250
Grand Total, F. M. S.		199,812	7,500

Straits Settlements.			
Penang ..	Balik Pulau ..	550	
P. Wellesley ..	Sungai Acheh.	358	
	Pulau Burong.	89	
	Total ..	447	2,000*
Dindings ..	Tanjong Burong ..	5,573	
	Batu Undan	1,130	
	Total ..	6,703	7,200
Malacca ..	C. Rachado ..	800	
	Linggi ..	10	
	Total ..	810	100
Singapore ..	Seletar North.	691	
	„ South.	394	
	Changi ..	264	
	Pandan ..	2,289	
	Keranji ..	810	
	Sungei Buloh..	1,090	
	Murai ..	80	
	Tuas ..	1,136	
		6,754	—
GRAND TOTAL, Straits Settlements.		14,714	9,300
Unfederated States.			
Johore ..	Sungei Pulai..	20,500	
	Kukub ..	1,600	
	Pendas ..	902	
	Sedili ..	1,070	
	Benut ..	6,500	
		30,572	1,000
Kedah ..	Merbok ..	13,747	
	Kisap ..	1,000	
	Kubang Badak.	700	
	Ayer Hangat..	700	
	Dayang Bunting ..	600	
		16,747	—
Kelantan and Trengganu ..	It is not possible to give even an approximation of the area of mangrove forests in these two states, as neither possesses a forest department and detailed surveys are lacking. It may, however, be safely assumed that the mangrove swamps—as in Pahang—are limited to the river mouths and are insignificant as compared with those on the west coast of the peninsula.		

* Mostly alienated.

GIRTH INCREMENTS.

The following table shows the average girth increments of the more important species, compiled from the records of sample plots in Perak and Selangor:

Girth in inches.	Bakau minyak.		Bakau kurap	Tumu.		Lenggadai	Berus
	Thinned.	Unthinned.	Unthinned.	Thinned.	Unthinned.	Thinned.	Thinned.
2—4	—	—	—	—	—	·350	·489
4—6	·813	·823	—	·726	·937	·669	·455
6—8	·934	·926	—	·693	·863	·631	·599
8—10	·923	·909	—	·649	·894	·653	·495
10—12	·889	·862	·700	·769	·732	·513	·388
12—14	·913	·825	1·000	·697	·640	·531	·409
14—16	·908	·812	·625	·629	·568	·508	·466
16—18	·732	·779	·711	·694	·542	·533	·385
18—20	·653	·722	·671	·800	·604	·509	·295
20—22	·715	·668	·869	·734	·653	·486	·100
22—24	·619	·644	·835	·725	·686	·567	—
24—26	·573	·645	·820	—	·724	—	—
26—28	·582	·518	·625	—	·685	—	—
28—30	·571	·582	·555	—	·911	—	—
30—32	·619	·609	·645	—	·666	—	—
32—34	·705	·693	·800	—	·730	—	—
34—36	·777	·523	·450	—	·300	—	—
36—38	·599	·624	·470	—	·310	—	—
38—40	·650	·684	—	—	·577	—	—
40—42	·567	·646	—	—	—	—	—
42—44	·925	·785	—	—	—	—	—
44—46	·635	—	—	—	1·250	—	—
46—48	·650	—	—	—	1·400	—	—
48—50	·650	—	—	—	—	—	—
Total trees ..	918	1064	85	146	280	476	382
Av. increment.	·798	·754	·752	·708	·714	·559	·449
The number of measured trees in each class was:							
2—4	—	—	—	—	—	1	12
4—6	47	23	—	25	16	43	23
6—8	93	45	—	29	26	52	45
8—10	135	82	—	18	23	57	99
10—12	137	112	1	18	21	73	91
12—14	83	102	3	15	25	66	61
14—16	45	92	4	12	25	72	31
16—18	38	105	9	9	19	56	13
18—20	41	89	11	10	26	37	6
20—22	46	84	13	8	16	15	1
22—24	41	84	17	2	21	4	—
24—26	45	75	9	—	20	—	—
26—28	36	46	4	—	17	—	—
28—30	36	30	4	—	9	—	—
30—32	31	30	4	—	7	—	—
32—34	24	22	3	—	1	—	—
34—36	18	13	2	—	1	—	—
36—38	10	8	1	—	2	—	—
38—40	3	13	—	—	3	—	—
40—42	3	7	—	—	—	—	—
42—44	2	2	—	—	—	—	—
44—46	2	—	—	—	1	—	—
46—48	1	—	—	—	1	—	—
48—50	1	—	—	—	—	—	—
Total ..	918	1064	85	146	280	476	382
	In all 3351 trees.						

APPENDIX B (*ii*).

GIRTH INCREMENT.

The following figures have been compiled from the annual girth measurements of trees in sample plots 1/12 at Matang, extending over a period of 5 years in the case of plots 1/3, and two years in the case of 4/12. *Bakau minyak*, *B. kurap*, and *Tumu* are included, as the plots are regarded as typical of the surrounding forest. Only dominant trees have been considered, as the dominated trees are likely to be killed out before the crop reaches maturity.

Girth class. (Inches).	Trees measured. (Number).	Annual girth increment in inches.		Time taken to grow into next class. (Years).	Maximum age of class. (Years).
		Total.	Mean.		
4 ins.	—	—	—	--	5*
4—6	63	51·33	·81	2·47	7·47
6—8	84	78·54	·93	2·15	9·62
8—10	86	70·97	·82	2·44	12·06
10—12	88	67·83	·77	2·59	14·65
12—14	78	54·76	·70	2·85	17·50
14—16	71	46·58	·65	3·07	20·57
16—18	98	58·99	·60	3·33	23·90
18—20	91	54.55	·60	3·33	27·23
20—22	101	58·36	·58	3·45	30·68
22—24	101	58·28	·58	3·45	34·13
24—26	81	46·16	·57	3·51	37·64
26—28	56	30·60	·55	3·64	41·28
28—30	34	19·01	·56	3·57	44·85
30—32	26	13·30	·51	3·92	48·77
32—34	11	5·84	·53	3·77	52·54
34—36	4	2·16	·54	3·70	56·24
36—38	6	4·04	·67	3·00	59·24
38—40	3	1·68	·56	3·57	62·81
TOTAL ..	1082	722·98	·67	—	—

* Plantation experience.

APPENDIX B. (*iii*).

Yield Table for Average Bakau.

The foregoing figures, together with the measurements of a large number of felled trees and countings in demarcated blocks, have been plotted and interpolated to form the following very approximate yield table for average *bakau* type forest. Wood below 8″ in girth is excluded.

Girth in inches.	Trees per acre.	Volume per tree. (c. feet).	Volume per acre. (c. feet).	Age of class. (years).	Mean annual increment (c. feet).
11	1700	—	—	—	—
12	1500	—	—	—	—
13	1080	—	—	—	—
14	940	—	—	—	—
15	830	2·8	2344	20	117
16	760	3·6	2736	22	124
17	700	4·2	2940	24	123
18	650	5·0	3250	25	130
19	620	5·9	3658	27	135
20	580	6·8	3944	29	136
21	550	7·8	4290	31	138
22	520	8·8	4576	33	144
23	500	9·8	4900	34	144
24	480	10·8	5184	36	144
25	460	12·0	5520	37	149
26	450	13·2	5940	39	152
27	430	14·4	6192	41	151
28	420	15·6	6552	43	152
29	400	16·8	6720	45	150
30	380	18·2	6916	47	147

It will be noticed that the mean annual increment culminates somewhere between the 26 and 28 inch girths and the 39th and 43rd years. This is considered to justify a rotation of 40 years.

Volume of timber on an area selected for conversion

1	2	3	4	5	6	7	8	9
Diameter. class. (inches)	Basal area of class. (sq. ft.)	Number of diameters. (2 per tree)	Double basal area of class. (sq. ft.)	Trees grouped by Hartig's Method.				
				Group No.	Diameter of class (inches)	Number of diameters.	Double basal area of class. (sq. ft.)	Double basal area of group. = 2 B.A.
3	·0491	66	3·24		3	66	3·24	
3½	·0669	109	7·29		3½	109	7·29	
4	·0873	298	26·02		4	298	26·02	
4½	·1105	398	43·98		4½	398	43·98	
5	·1364	556	75·84		5	324	44·20	
5½	·1650	496	81·84					
6	·1963	250	49·07					
6½	·2304	292	67·28	I		1195	—	124·73
7	·2673	102	27·26					
7½	·3068	179	64·91					
8	·3491	78	17·23		5	232	31·64	
8½	·3941	111	43·74		5½	496	81·84	
9	·4418	45	19·88		6	57	11·19	
9½	·4923	54	26·68					
10	·5454	28	15·27					
10½	·6014	24	14·43	II		785	—	124·67
11	·6600	10	6·60					
11½	·7214	12	8·66					
12	·7854	3	2·36		6	193	37·88	
12½	·8523	5	4·26		6½	292	67·28	
13	·9218	4	3·69		7	73	19·51	
13½	·9941	2	1·99					
14	1·0690	2	2·14					
				III		558	—	124·67
					7	29	7·75	
					7½	179	64·91	
					8	78	27·23	
					8½	63	24·83	
				IV		349	—	124·72
					8½	48	18·91	
					9	45	19·88	
					9½	54	26·68	
					10	28	15·27	
					10½	24	14·43	
					11	10	6·60	
					11½	12	8·66	
					12	3	2·36	
					12½	5	4·26	
					13	4	3·69	
					13½	2	1·99	
					14	2	2·14	
				V		237	—	124·87
Total	—	3124	623·66	—	—	3124	—	623·66

10	11	12	13	14	15	16	17
Mean Sample Trees.			Real Sample Trees.				
Basal area. (sq. ft.)	Diameter (inches)	Group No.	No.	Diameter. (inches)	Basal area. = b.a. (sq. ft.)	Volume. = v. (cu. ft.)	Volume of groups $V = \frac{v \times BA}{ba}$ (cu. ft.)
		I	1	4·30	·1009	2·67	
			2	4·35	·1032 } ·3073	2·22 } 7·44	1510
			3	4·35	·1032	2·55	
		II	4	5·45	·1620	5·37	
			5	5·45	·1620 } ·4772	4·83 } 14·94	1973
·1044	4·4		6	5·30	·1532	4·74	
		III	7	6·25	·2130	7·83	
			8	6·30	·2164 } ·6390	7·82 } 23·18	2261
			9	6·20	·2096	7·53	
		IV	10	8·20	·3668	13·57	
			11	8·00	·3491 } 1·0650	10·31 } 34·96	2047
·1588	5·4		12	8·00	·3491	11·08	
		V	13	9·45	·4871	18·25	
			14	10·10	·5564 } 1·5514	19·77 } 54·84	2207
			15	9·65	·5079	16·82	
·2234	6·4				**Total volume of timber:**		**9,998 c. ft.**

Half of the area selected is in sub-coupe 8/11 and the other half in 9/12. At the time of measurement (March 1927) the average age of the trees was between 14 and 16 years, but there were groups of advance growth and standards that were obviously older.

Each tree was callipered twice and both measurements recorded.

The number of trees and total basal areas in columns 3, 4, 7, and 9 must, therefore, be divided by two if the true figures are required.

The total volume of timber left standing is 9,998 cubic feet, excluding stumps and everything under 8″ in girth. At 72 lbs. per c. foot (Chap. VI. e) this is equivalent to .. .. 321 tons.

·3574 8·1

There were removed in the form of thinnings:

Firewood (138 tons railway weights, 65 tons *sampan* weights, and 16 tons abandoned) .. .. 219 „

Poles (2,452 from 1′ to 2′, 4,247 from 4′ to1′, and 195 under 4″, at 25, 100, and 1,000 p. ton). As only wood over 8″ in girth is considered utilisable allow say: .. .. 120 „

Total per acre 65 tons TOTAL .. 650 tons.

·5268 9·8

The figures for the outturn from thinnings must be accepted with caution owing to delay and bad work on the part of the contractors concerned.

An average of 65 tons per acre is exceptional for 16 year forest, but it must be remembered that this area was selected on account of its even stocking and 100% productivity—conditions that do not obtain over extensive areas. The plot also carried a considerable number of standards, which were removed with the thinnings, and account for the relatively high outturn. Further, under permit or licence, exploitation would never be so thorough as it was in this case.

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APPENDIX C.

ASSESSMENT OF PREMIA PAYABLE ON SUB-COUPES.

Maximum premium. This is based on the probable yield per acre from the productive area. The area is traversed by the District Forest Officer, who makes an ocular estimate of its possibilities and decides on the productivity or otherwise of any part of it. The following table shows the maximum payable on the most accessible sub-coupes, *i.e.*, those within easy reach of a road or railway.

Probable yield in pikuls per acre. (100 pikuls=approximately 6 tons.	Premium payable in dollars per acre. ($1/- = 2/4).	Equivalent in dollars per 100 pikuls.
500	22·50	4·50
600	25·00	4·16
700	27·50	3·93
800	30·00	3·75
900	32·50	3·61
1000	35·00	3·50
1100	37·50	3·41
1200	40·00	3·33
1300	42·50	3·27
1400	45·00	3·22
1500	47·50	3·17
1600	50·00	3·12
1700	52·50	3·09
1800	55·00	3·06
1900	57·50	3·03
2000	60·00	3·00

It will be noticed that the premia are proportionately higher for the low yielding areas. This balances a tendency to underestimate the yield, experience having shown that it is very unusual for sub-coupes to be assessed too high. It also acts as a corrective to wasteful exploitation, the low yields being usually largely attributable to the abandonment of utilisable wood. Really poor areas are assessed on their merits and are, moreover, compensated by abatements in other directions.

Abatements. The maximum premium having been fixed according to the above table, abatements are allowed according to the distance of the sub-coupe from the nearest road or railway. As the transport *sampans* are almost entirely dependent on the tides, it is time rather than distance that must be considered, and the abatements are, therefore, based on the number of favourable tides that must flow between the time of departure from the sub-coupe, and the time of arrival at the unloading station. Thus, if a fully laden *sampan* can start off and reach its destination on the same tide, the area is described as a one-tide sub-coupe; if it is necessary to tie up and wait for the next tide it is called a two-tide sub-coupe; if it is not possible to get there without tying up for a second time it is a three-tide sub-coupe; and so on. Four tides is the maximum for even the remotest areas. The abatements are as follow:—

For 1 tide	Nil.
„ 2 tides	$10 per acre.
„ 3 „	$20 „ „
„ 4 „	$30 „ „

A further allowance of not more than $5 per acre is made in respect of areas that are not well provided with natural waterways, that consequently require the construction of expensive extraction canals, or that are otherwise awkward to work.

An example of a valuation will be found in Appendix D.

APPENDIX D.

PARTICULARS OF SUB-COUPE *No.* 11 *Year* 1926

(*a*) Valuation.

1. POSITION (a) Felling Series Pasir Jeremal.
   (b) Locality Sungai Anu.

2. AREA (a) Exploitable 75 acres

   (b) Not exploitable or non-productive
   - (i) Hutan darat 10 ,,
   - (ii) Water 2 ,,
   - (iii) Other *(Immature)* 13 ,,

   TOTAL AREA 100 ,,

3. DESCRIPTION OF CROP: Mature *bakau minyak* with *lenggadai* near streams. A group of immature forest in the S.E. corner. In the N.E. corner near the *hutan darat* there are some large *tumu*.

4. FACTORS OF LOCALITY: Soil, soft mud with some clay in the South, sandy inland to the North. Majority of area in inundation Class 3.

5. ESTIMATED OUTTURN:

   Average, (for area 2 (a) only) 1,300 pikuls per acre.

6. DISTANCE FROM DISTRIBUTING CENTRE (Port Banat) 3 tides.

7. EXTRACTION FACILITIES (a) Internal Poor.
   (good or bad) (b) External Good.

		per acre.
8. PREMIUM PAYABLE ON CROP AS PER (5) above (See Appendix C)		$42 50
Deduct for 3 tides as per (6)	$ 20 00	
,, ,, inaccessibility ,, (7)	$ 2 00	
,, ,, other reasons.	$ ———	
TOTAL DEDUCTIONS		$22 00
NETT PREMIUM		$20 50
TOTAL PREMIUM PAYABLE (on 2 *(a)* only).	$1,537 50	

(Signed) J. JONES,
Forest Officer.

Date, 2nd July, 1926.

(*b*) Results of Exploitation.

9. YIELD	(a) Firewood	5,999 tons	Average per acre from productive area 80.30 tons = 1,348 pikuls.
	(b) Poles	23 ,,	
	Total	6,022 ,,	

10. FINANCIAL STATEMENT.	Premium	$1,537	50
	Royalty ..	$3,146	00
	Sub Licences ...	$ 50	00
	Compensation ...	$ 75	00
	TOTAL REVENUE	$4,808	50 = $48.09 per acre.

(*c*) Reports.

11. Closing report. Coolies left coupe by 31-8-27. Exploitation reasonably satisfactory. 5 *sampans* of wood left in block II on which royalty has been paid.

12. Regeneration prospects and recommendations. Satisfactory Standards retained in *piai* area adjoining the *hutan darat* and in the south where the flooding is exceptionally deep. Elsewhere regeneration can be expected to look after itself with the possible exception of a patch of about 5 acres, marked P in the map, where planting may be necessary.

(Sd.) T. DAPPER,
Forest Officer.

Date, 15–9–27.

13. Subsequent inspections and operations—	Cost $	cts.
7- 7-28. Regeneration on the whole satisfactory except for about 3 acres in block II. (Ind.) T.D.		
9-11-28. Planting 2.8 acres with *B. minyak* 6'×6' on contract @ 6-per acre. (Ind.) T.D.	14	80
22- 3-29. Supplies will be necessary. (Ind.) J.J.		
15-11-29. Supplied with 926 *B. minyak* by forest labourers. (Ind.) J.J.	3	20
4- 6-30. Inspected—No more planting needed. (Ind.) M.S.		

D. F. O. No. 153-26
D. C. F. No. 221-26
C. F. No. 944-26

(*d*) History of Sub-Coupe No. 11-26.*

1. Area 100 acres, less 25 acres;

productive area 75 acres

Date.		Revenue.		Expenditure.	
		$	cts.	$	cts.
15- 8-26	Opened by Chong Fatt Huan				
31- 8-27	Closed. Total revenue (as over page) ...	4,808	50	...	...
9-11-28	Planted 2.8 acres	...	...	14	80
25-11-29	Supplied	...	..	3	20
4- 6-30	Regeneration complete	...	...	..	...
3- 2-42	30 acres opened for thinning with 5′ stick by Mat Desa (Block III). Demarcation.	...	...	1	75
25-12-42	Pole-coupe closed ; outturn 29 tons ...	95	40	...	...
17- 9-50	35 acres thinned by fishermen from Bagan Busok ; outturn 18 tons ; free	...	...	...	...
1- 8-65	90 acres opened for final thinning with 8′ stick by Ng Wang Thian	...	...	...	...
30-11-66	Closed ; outturn 543 tons firewood, 321 tons poles ; revenue, including permit fees and compensation	879	00	...	...

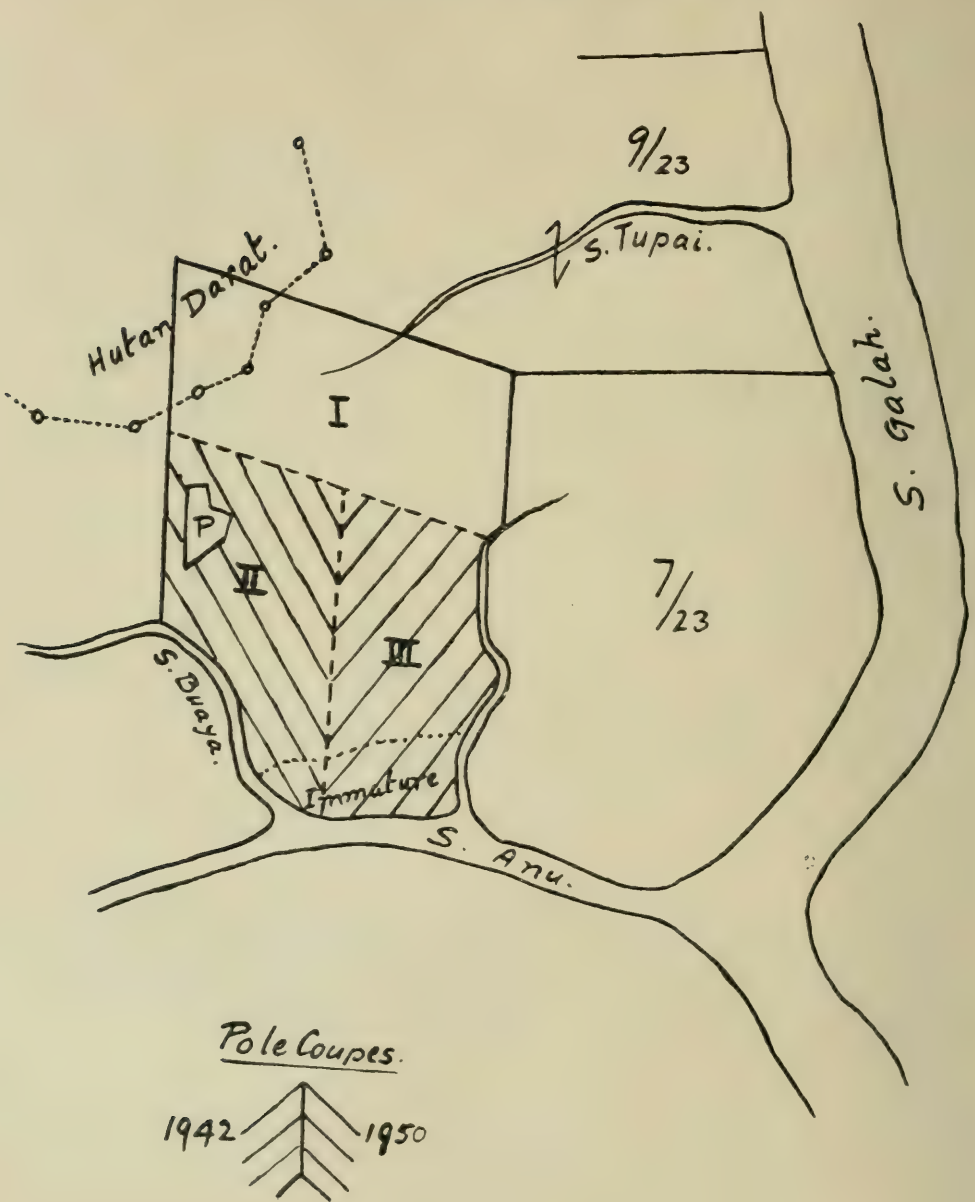
* *Note.* Theoretically the sub-coupes preserve their identity from the time that they are opened for exploitation until they have completed the rotation and are again ready for felling. Not being permanent units their subsequent treatment depends on the felling programme and the condition of the surrounding forest. Whether they are worked again as a whole, or split up and divided amongst other sub-coupes, their old numbers will be discarded and new ones given as soon as final felling starts.

APPENDIX D.

SUB-COUPE 11/26

PASIR JEREMAL

Productive area 75 acres.



APPENDIX E (*i*).

PERMIT

TO CUT TIMBER AND FIREWOOD IN FOREST RESERVE.

Issued under Rule 35 of the "Forest Rules 1925."

..... (hereinafter called the Permit Holder) is hereby permitted for a period of ..... months from the date of this permit either personally or through his employees to cut and remove trees and timber under the conditions and with the exceptions herein set forth within the areas delineated in the first schedule hereto attached (hereinafter called the sub-coupe). Provided that should the sub-coupe be completely exploited before the..... the permit shall thereupon terminate.

1. For the purpose of this permit the girth measurement of a tree shall be understood to be its girth taken as nearly as possible at a height of 4½ feet from the ground or, in the case of trees with stilt roots higher than 4½ feet, at a height of 4 inches above such roots.

2. The District Forest Officer, ... may (*i*) authorize any Forest Officer at any time either (a) to mark and reserve from felling and damage, or (b) to require the Permit Holder to reserve from felling and damage all or any trees of any species and size up to a maximum number of two per square chain or/and (*ii*) prohibit the felling of all or any trees being less than 15 inches in girth.

3. No employee of the Permit Holder engaged in the cutting or removal of timber and firewood from the sub-coupe shall work or reside within the sub-coupe unless he has in his possession a permit in the form of the second schedule hereto.

4. For purposes of exploitation the sub-coupe may be divided into blocks by the District Forest Officer,..... and, in the event of such division being made, not more than two of the blocks shall be exploited simultaneously, except with the written permission of the said District Forest Officer.

5. Except as otherwise provided in this permit all trees in any part of a block entered upon for exploitation shall be felled without selection and completely converted, and the timber and firewood from such trees completely extracted. The Deputy Conservator of Forests, ...(hereinafter called the Deputy Conservator) may order the immediate felling, conversion and extraction of any trees, timber, or firewood left in any block under exploitation in contravention of this clause, and may prohibit

further felling for failure to convert trees already felled, or to extract the timber and firewood obtainable from such trees, or otherwise to comply with the provisions of this clause. No tree shall be deemed to be completely converted if timber of 8 inches in girth or over remains unutilised.

6. If in the opinion of the District Forest Officer.....the conversion and removal of felled trees or timber are unreasonably delayed he may order all further felling to cease until the conversion and removal of trees already felled shall have been completed.

7. The boundaries of the sub-coupe and of the blocks shall not be obstructed, and any tree which falls across a boundary must be immediately removed by the Permit Holder.

8. The forest officer or officers residing in or near the sub-coupe for the purpose of supervising the work of the Permit Holder shall be entitled to receive from the employees of the Permit Holder residing in the coupe four gallons of fresh water daily.

9. All timber and firewood removed from the sub-coupe may be detained wherever found by any forest officer for purpose of check and for enquiry.

10. In the event of any dispute arising as to the size or species of any tree felled or damaged, or as to the number of trees which should have been left standing on any portion of the sub-coupe as required by clause 2 hereof, the decision of the Deputy Conservator shall be final.

11. *a.* (*i*) Except with the written permission of the Deputy Conservator all timber and firewood shall be delivered to..... and shall not be removed from there unless it has been weighed on the railway weighbridge and a railway consignment note issued in respect of it, or

(*ii*) No timber or firewood shall be removed from the sub-coupe unless accompanied by a Removal Pass in Form V of schedule II of the Forest Rules, 1925.

b. No ship or boat shall be used to transport timber or firewood from the sub-coupe the number of which has not been notified to the District Forest Officer.

12. The Permit Holder shall pay to the District Forest Officer, monthly, or on demand, royalty on all timber and firewood cut in, or removed from, the sub-coupe at the following rates:—

Timber, 2′ in girth and over	50	cts. per ton.
Poles, 12″ or more, but less than 24″ in girth	25	„ „ 100′ run.
„ 4 „ „ 12 „	12½	„ „ „ „
„ less than 4″ in girth	50	„ „ 100 pieces.
Firewood	$3.00	„ 100 pikuls.

13. The Permit Holder shall also pay to the District Forest Officer a sum of $ by way of premium, in equal monthly instalments. Such instalments shall be paid before the 15th of each month.

14. The Permit Holder shall be liable to pay the District Forest Officer on demand by the Deputy Conservator of Forests, by way of liquidated damages:—

(*i*) A sum not exceeding $50 for every tree in respect of which the Permit Holder breaks or fails to fulfil the conditions of clause 2 (*i*).

(*ii*) A sum not exceeding 25 cents for every tree felled in contravention of clause 2 (*ii*).

(*iii*) A sum not exceeding $5 per tree for every completed week during which any tree shall remain unfelled after an order to fell it has been made by the Deputy Conservator under clause 5.

(*iv*) A sum not exceeding the royalty on all timber left in the sub-coupe in contravention of clause 5, one week after an order for its removal has been issued by the Deputy Conservator of Forests. This payment shall be in addition to royalty payable under clause 12.

(*v*) A sum not exceeding $5 in addition to royalty on timber for every tree cut or broken after the District Forest Officer has given an order for work to cease, under clause 6 or 16, or for any tree felled in contravention of clause 4.

(*vi*) For every breach of clause 7 a sum not exceeding $5 for every day during which the obstruction shall continue.

(*vii*) A sum not exceeding $250 for removal, or delivery, or attempted removal or delivery, of timber or firewood otherwise than in accordance with the provision of clause 11 (*a*) and 11 (*b*) of this permit.

15. The Permit Holder shall deposit monthly with the District Forest Officer, a sum equivalent to 10% of the amount of royalty payable in that month, until the total amount so deposited shall amount to $.....(Dollars.....) with a minimum of 60 cents per acre of the area of the sub-coupe. Such deposit shall be a guarantee for the due fulfilment of this permit by the Permit Holder. The Deputy Conservator may withdraw from the said deposit any monies payable under this permit and any monies withdrawn by the Deputy Conservator shall be replaced by the Permit Holder within five days.

16. In the event of any money due by the Permit Holder under this permit remaining unpaid after a period of five days from the day on which the Permit Holder receives the notice of demand the District Forest Officer may stop all further felling or removing of trees or timber on or from the sub-coupe or from the railway yard at.....until such sum has been paid.

17. (*i*) Should the royalty payable under clause 12 of this permit amount in any two consecutive months after.....to less than dollars.....($.....) per mensem, the Permit Holder may be called upon by the District Forest Officer to deposit a sum equivalent to the deficiency. In the event of exploitation not being complete within the period of the permit such deposit shall be forfeited to the Government, provided that if the permit be extended beyond the date of expiry the forfeiture shall be as provided in clause 17 (*iii*).

(*ii*) Should the royalty paid under clause 12 at any time during the period of this permit, but not during the period of any extension, exceed the total amount required by clause 17 (*i*) a sum equivalent to that excess shall be refunded to the Permit Holder from any deposit that may have been made under that clause, provided that the refund shall in no case exceed the amount of that deposit.

(*iii*) Should this permit be renewed after expiry the balance forfeited under (*ii*) above will remain on deposit until the area has been completely exploited. The Deputy Conservator of Forests may then, at his discretion, refund to the Permit Holder a sum not exceeding one tenth of the said deposit for each complete month by which the period of extension is less than ten months.

18. Should the Permit Holder contravene any clause of this permit or fail to pay any money payable under it, this permit shall be liable to cancellation by the Conservator without prejudice to any action that may be taken for the recovery of any money due

hereunder. In the event of cancellation of the permit under this clause the Conservator shall not be liable for any loss sustained by the Permit Holder, and all monies paid by the Permit Holder by virtue of this permit shall be forfeited to the Government.

CONSERVATOR OF FORESTS,
F. M. S. & S. S.

Kuala Lumpur,.....*192*.....

I HEREBY AGREE TO BE BOUND by all the terms and conditions of this permit.

Signature of Permit Holder.

Date,.....192.....

Signature of Witness.

FIRST SCHEDULE

An area of approximately.....acres known as Sub-coupe.....in the.....Mangrove Forest Reserve.

(Map of Sub-coupe).

(This space is for a map of the sub-coupe and its environs).

SECOND SCHEDULE.

(Valid for 90 days from day of issue)

No.....

.....is hereby permitted to enter sub-coupe No.....of the.....Mangrove Forest Reserve and to cut and remove timber and firewood therein as an employee of .....

.....

Date of issue.....1927.

.....

Forest Officer.

Fee. Fifty cents only.

APPENDIX E. (*ii*).

AUTHORISATION TO CUT POLES IN.....FOREST RESERVE.

(*Issued under Forest Rule* 35.)

In consideration of a monthly payment in advance of $5/- (dollars five only) and subject to the issue of a licence renewable monthly,.....is hereby authorised for a period of not more than 12 months to cut trees in and to remove the cut trees from that part of the..... Forest Reserve indicated in the plan at the back of this permit, subject to the following conditions:—

1. That no tree be cut unless a sound tree of the same or larger girth and the same or superior class is left standing undamaged within a distance to be prescribed from time to time in writing by the Deputy Conservator of Forests.....Provided that any..... .....tree over..... inches in girth may be felled if another sound tree is left undamaged within the prescribed distance.
2. That in addition to the payments mentioned in the preamble royalty shall be paid at the following rates:—
   (*a*) $3.00 per 100 pikuls for firewood.
   (*b*) 25 cents per 100 feet length of poles of 1′—2′ girth.
   (*c*) 12.5 cents per 100 feet length of poles of 4″—1′ girth.
   (*d*) 50 cents per 100 poles for poles under 4″ girth.
3. That for every breach of condition (1) the holder shall be liable to pay liquidated damages not exceeding $5/- per tree.
4. That work under this authorisation be subject to the Forest Enactment and Rules regulating the felling and removal of timber and firewood from State Land, except in so far as they may be relaxed by the Deputy Conservator of Forests,....., or may be repugnant to the conditions of this authorisation, and that the holder be held responsible for all breaches by his employees of the Forest Enactment and Rules or of the conditions of this authorisation.
5. That this authorisation may be cancelled at any time by the Conservator of Forests, F. M. S. & S. S. for breach of any of its conditions.

CONSERVATOR OF FORESTS,
F. M. S. & S. S.

Kuala Lumpur,.....192 .

Note.—For the purposes of Clause (1) trees shall take the following precedence:—

Bakau, Tumu, Berus, Lenggadai.

APPENDIX E. (*iii*).

FISHING STAKE PERMIT.

No.....

FREE PERMIT TO TAKE FOREST PRODUCE.

(NOT TRANSFERABLE.)

.....

of.....is hereby permitted to take from.....the forest produce hereunder described subject to the provisions of "The Forest Rules, 1920," and to the conditions stated on the reverse.

Kind of produce.....
Quantity.....
Purpose.....
Date of issue.....
Date of expiry.....

.....

Forest Officer.

(Reverse).



大凡有地上者入號牌竪准

Entry into areas indicated by notice-boards bearing the above mark is prohibited.

دتكهكن ماسق ددالم كاواسن٢ اتو تمڤة٢ يغبرتندا
ددالم ڤاڤن نوتيس سڤرت دأتس اين اداڽ.

APPENDIX E. (*iv*).

PERMIT TO COLLECT BARK.

With the approval of the Conservator of Forests F.M.S. & S.S. .....of.....is hereby permitted to collect the bark and timber of Nyireh bunga / Tengar trees and to remove them from the.....Mangrove Forest Reserve subject to the following conditions:—

1. That he pays —$10 / $15— per calendar month in advance for a licence on which the area on which he may work will be specified.
2. That no —Nyireh bunga / Tengar— tree be cut unless its girth, measured at 4½ feet from the ground, exceeds 2 feet / 1½ feet and that every tree so cut shall be felled and its bark stripped to the satisfaction of the District Forest Officer.
3. That no other tree shall be cut for any purpose whatever.
4. That he keeps the licence on him while at work and allows no-one, unless he has a similar licence, to handle in any way any bark or timber of the trees cut under licence until such bark or timber reaches the shore at a fishing village or the mainland.
5. That he removes no timber from the spot where the tree is felled until the bark has been stripped from it.
6. That this permit may be cancelled at any time by the Conservator of Forests, and that in the event of its cancellation for any default on the part of the permit holder or his agents or workmen he shall have no claim to damages or to the refund of any money paid to or deposited with the Government.

.....

Deputy Conservator of Forests.

Dated.....

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